

Pharyngealization in Libyan (Tripoli)

Arabic; an instrumental study

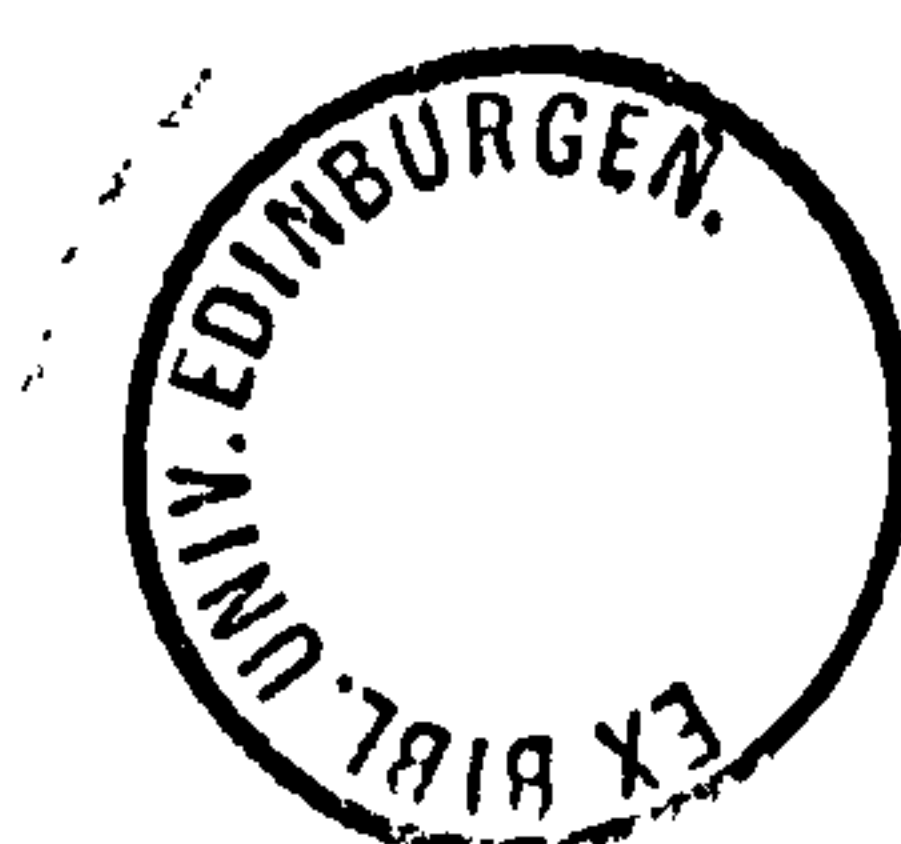
WIDAD JUMA LARADI

A thesis submitted for the degree

of Doctor of Philosophy

University of Edinburgh

1983

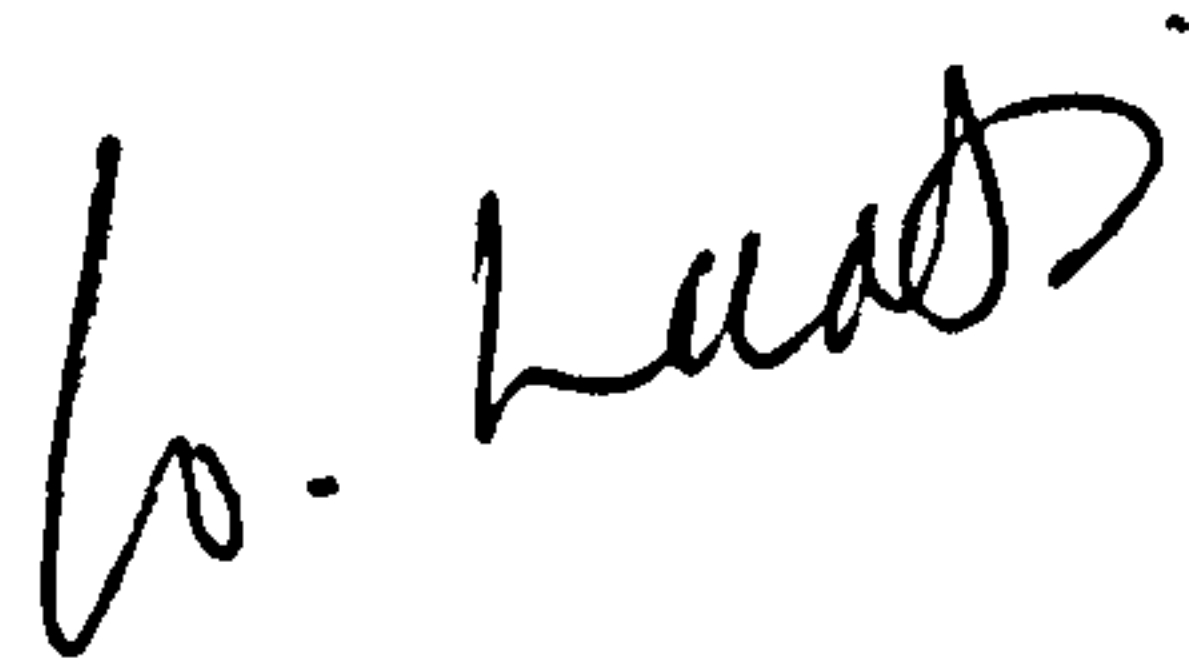


To the memory of my father

Declaration

This thesis is my original work and of
my own execution and authorship.

WIDAD JUMA LARADI

A handwritten signature in black ink, appearing to read 'W. Laradi', written in a cursive style.

Acknowledgements

I wish to thank Professors David Abercrombie and James Hurford for their valuable suggestions at the early stage of this work.

I am greatly indebted to my supervisor, Dr. James Anthony, for his constructive and valuable comments and constant encouragement and for being very generous with his time.

Special thanks are due to Jeff Dodds of the Phonetics Laboratory, Edinburgh University for being patient and meticulous in providing me with all the prints that appear in this thesis.

My thanks are also due to Doctors Siddig Rtemi, Ahmed Shah of Ibn Nafis Hospital, Tripoli, Libya, to Dr. Roger Wilde of the Royal Hospital for Sick Children, Edinburgh and to Dr. Frances MacCurtain of Middlesex Hospital, London, for providing me with radiographic facilities.

I am grateful to my subjects, Mr. Saad Ali, Dr. Jawad Sarrag and Dr. Fikri Laradi for willingly and patiently providing me with the experimental data.

My deep gratitude and love go to my mother, my sisters, my brothers and my grandmother for their constant encouragement and support throughout my absence from home.

Abstract

This thesis aims to study the phenomenon of pharyngealization in Arabic, in the dialect of Tripoli, Libya in relation to other dialects of Arabic. The term 'pharyngealization', as used in this study, refers to all the sounds whose main articulatory requisite is a constriction in the pharyngeal cavity. This is a physiological and articulatory study based primarily on observations made on video-endoscopic and video-fluorographic recordings; spectrographic analysis, palatographic and airflow measurements also contributed.

Chapter 1 states the aim and scope of this thesis. It defines the dialect studied and describes some of the main aspects of the sound system of Tripoli Arabic.

Chapter 2 gives a description of the main structures and muscles and their actions that are considered to, directly or indirectly, play the major role in the production of these sounds.

Chapter 3 describes the experimental techniques used in this study: a) fiberoptic endoscopy with video-recording b) X-ray recording; static, xeroradiography and videofluorography c) airflow recording by pneumotachography d) palatography e) labiography and f) spectrography.

Chapter 4 deals with the pharyngeal consonants and studies certain issues related to their phonetic realizations and to the role of the epiglottis in their production.

Chapter 5 describes the uvular consonants. Endoscopic observation revealed a great side wall movement of the pharynx occurring during the articulation of the uvular /q/, which takes place at a superior level in the pharynx.

Chapter 6 deals with the pharyngealized consonants, divides them into primary and secondary and attempts to show that a large part of the problem in the description of these sounds stems from a phonemic split in the vowel /a:/.

Chapter 7 discusses the main findings in this study and shows, among other things, that a great epiglottopharyngeal constriction is the main articulatory requisite in the articulation of the pharyngeal sounds in Arabic, irrespective of other factors. It also attempts to determine to what extent soft palate lowering and nasal airflow are coterminous with the articulation of the pharyngeal sounds.

CONTENTS

Chapter 1: Introduction	1
1.1. Aim and scope	1
1.2. The dialect	3
1.3. The sound system of TA	8
1.4. Consonants	9
1.5. Vowels	15
1.6. Syllable structure	24
1.7. Consonant clusters	26
1.8. Gemination	30
1.9. Assimilation	33
1.10 Stress	36
Chapter 2: Structures and Muscles	38
2.1. Introduction	38
2.2. The pharynx	39
2.3. The epiglottis	43
2.4. The hyoid bone	51
2.5. Tongue	53
2.6. The soft palate	56

Chapter 3: Experimental Techniques	58
3.1. Fibreoptic endoscopy	59
3.2. X-ray	71
3.3. Xeroradiography	73
3.4. Videofluorography	79
3.5. Spectrography	81
3.6. Palatography	83
3.7. Labiography	84
3.8. Airflow, pneumotachography	85
3.9. Pneumotachography coupled with videofluorography	86
3.10 Subjects	87
Chapter 4: The Pharyngeal Consonants	88
4.1. Views related to the epiglottis	92
4.2. The role of the epiglottis in the production of pharyngeals	94
4.3. Nasalization related to pharyngeals	105
4.4. The controversy related to /3/	111
4.5. Results of experimentation	122

Chapter 5: The Uvular Consonants	177
5.1. The uvular /q/	182
5.2. The uvulars /X/ and /g/	202
Chapter 6: The Pharyngealized Consonants	212
6.1. The primary pharyngealized consonants	216
6.2. The secondary pharyngealized consonants	219
6.3. Results of experimentation	229
Chapter 7: Discussion and Conclusions	273 287
Appendix I	332
Appendix II	339

CHAPTER I

Introduction

1.1 Aim and scope

The aim of this work is to study the phenomenon of pharyngealization in the dialect of Arabic spoken in Tripoli, Libya, henceforth, (TA). The term 'pharyngealization' is used here in its broadest sense to cover those consonants that are articulated by a constriction or otherwise in the pharynx from soft palate to larynx irrespective of other factors, as in the case of the pharyngealized consonants which involve a primary articulation of tip or blade of tongue and a secondary articulation of tongue root besides factors of lip rounding or protrusion that undoubtedly have acoustic consequences. All sounds of this type are to be treated under this general heading. The use of this term is justified on the basis that the articulation of these sounds takes place in the pharynx wherever the part involved may be.

Constrictions of the vocal tract are generally known to take place in the front part, i.e., from lips to velum, taking the back part to mean the vertical passage between velum and glottis, i.e., the pharynx (see 2.6 for a description of the pharynx). Thus, consonants made by a

constriction in the pharynx, wherever the part may be are not common, Delattre (1971), Klatt and Stevens (1969), Ladefoged (1971). However, these consonants form a relatively large proportion of the sound system of those languages that have them. For instance, in Ubykh, one of the Caucasian languages, there are 29 pharyngeal consonants out of its 80 consonants, Catford (1981). Arabic, whether classical or dialectal, possesses a large number of consonants made in the pharynx. These consonants on which this work is based can be classified according to the traditional classification into three groups:

a) the voiceless and voiced uvular fricative consonants /x/ and /g/, and the voiceless uvular stop /q/, which are articulated by a superior retraction of the tongue dorsum towards the soft palate, b) the voiceless and voiced fricative pharyngeals /ħ/ and /ʕ/, which are made by a constriction of the pharynx at the level of the epiglottis against the posterior wall of the pharynx and c) the pharyngealized consonants where a constriction in the oropharynx as a result of the retraction of the root of the tongue is the main factor involved.

1.2 The dialect

Although much has been written on the history and politics of Libya, relatively little has been published on the linguistic side. The early scholars of Libya devoted their work to the study of Classical Arabic. The spoken variety was and still is considered inferior to the Classical Arabic, and the intention was to encourage people to use the Classical Arabic by opening 'Kittabs' or Koranic schools where children learned the teachings of the Koran, as well as the rules of the grammar of Classical Arabic.

When the Italians came to Libya in 1911, new interest in spoken Libyan Arabic arose. Writers like Griffini (1913), and Panetta (1943), gave descriptions of two varieties, namely those of the two main cities, Tripoli and Benghazi. Later on, Mitchell wrote about the Arabic spoken in Cyrenaica (1952). In recent years, research on the spoken varieties of Libyan Arabic started and has progressed through postgraduate studies taken abroad, Elfitouri (1976), and Sweid (1977). However, this is mainly carried out on the grammar of these dialects. To the author's knowledge, no instrumental phonetic study has so far been carried out apart from an acoustic study of the voiceless fricatives of Zelitina Arabic, Krieg, et. al., (1980). Other early works on Libyan Arabic were not available for consultation, but are included in the bibliography.

The Italian descriptions of the Arabic of Libya were almost entirely devoted to grammar and lexicon. Griffini, for instance, was not aware that he confused the Tripoli Arabic with that spoken in Tunisia. This may be a result of his use of Stummes work (1898), as a reference which includes examples of Tunisian Arabic.

Griffini (1913), devotes his book mainly to the lexicon of TA, with an alphabetical listing of the lexical items. However, there is included an introduction to the language, the sound system of TA, the morphology and the writing system. His description of the consonants and vowels is auditorily based, and made in terms of Italian and German vowels. His monophthongs and diphthongs are given below. He divides them into short unstressed, short stressed, long unstressed, long stressed, very long stressed, very short unstressed, auxiliary very short unstressed, stressed and unstressed diphthongs. He uses the terms 'chiara' and 'aperta' as open, and 'chiusa' as close, to indicate the tongue position of being open or close.

a	an open a
ä	intermediate between a and e
ɛ	an open e
e	close e
ɛ̄	intermediate between e and i
i	an open i
y	intermediate between i and u

ÿ	intermediate between the Italian u and the German ü
u	an open u
ũ	intermediate between u and o
o	an open o
ø	a close o
ô	intermediate between close o and a
ë	the German close ö
ö	the German open ö
āu, ōu	diphthongs made of the vowels a and o with the consonant w functioning as a vowel
āī, ēī	diphthongs made of the vowels a, e with the consonant j functioning as a vowel
a, e etc.	short unstressed vowels
á, é etc.	short stressed vowels
ā, ē etc.	long unstressed vowels
â, ê etc.	long stressed vowels
â~, ê~ etc.	very long stressed vowels
ă, ě etc.	very short unstressed vowels
ǎ, ě etc.	auxiliary very short unstressed vowels
āu, ēī	unstressed diphthongs
áu, éí	stressed diphthongs

In this thesis, the author attempts to give a description of certain features of the most common variety spoken in the city of Tripoli; which she and her informants speak, except for subjects (SA) who speaks Iraqi Arabic of Basra, and (MB) who speaks the Yemini Arabic of Hadramaut.

Tripoli is the largest city in Libya with a population of over one million. It is a very old city which became an important commercial centre for the Phoenicians around 1000 B.C. For a long time, it was occupied consecutively by various invaders who left their mark on the life and the culture of its people. The Arabs came in 643, and spread Islam and the Arabic language and although the city was later invaded by the Spaniards, Knights of St. John Hospitallers, the Turks and the Italians, Tripoli and the rest of the country kept its identity as an Arabic country.

Tripoli is not a unified dialect area and other varieties of Libyan Arabic exist alongside TA, namely the varieties spoken by the Libyans who moved from other towns and villages and settled in Tripoli. Although they acquired in their speech features specific to TA, they however, still retain most of the features of their original dialects. This becomes apparent in their communication among each other.

TA is spoken by a large proportion of the population in Tripoli, but mainly the literate people, in their everyday life. Some degree of modification is required according to the social and cultural situation, that is problems of diglossia which can arise even within the one dialect area.

TA undergoes changes all the time; these changes are partly a consequence of foreign invasions, mainly by the Turks and the Italians; and partly a consequence of mixing and intermarriage of Arabs and Berbers, the original inhabitants of Libya.

Loan words from Turkish and Italian have become part of the lexicon of TA. Nowadays, there is a tendency towards arabicising these loan words, and more people are found to use Arabic words instead, either borrowed from Classical Arabic or another Arabic dialect. The influence of Berber is thought to be only in pronunciation, for example, the use of two or more consonantal clusters in syllable initial position. On the other hand, the influence of Arabic on Berber is thought to be greater; Berber scholars were to become well known on their works on Arabic and in Arabic language.

There is a tendency for some illiterate people to use certain words, normally part of the lexicon of literate people, which they acquire from their school children,

radio or television. They may be borrowed from Classical Arabic or another dialect of Arabic, but for one reason or another, they are used frequently either in the media or as a result of mixing with other Arabs who speak different dialects. A good example would be the returning of Libyans, whose ancestors emigrated to other Arab countries in the past, namely the large number of Libyans who came back from Tunisia more than twenty years ago, who brought back with them their speech habits; also, the great number of Egyptians who came to work in Libya in the early seventies. However, the exposure to the Egyptian dialect took place much earlier than that, mainly through the radio and films, not to forget the role the Egyptian and Palestinian teachers played, and still do, in education which was mainly done by them.

The extent of influence of these languages on Libyan Arabic and the result of incorporating some of their features as part of the language cannot be ignored.

1.3 The sound system of TA

In this chapter, the basic aspects of the sound system of TA are outlined and discussed. The consonant and vowel phonemes are identified and described. Syllable types are classified and consonantal clusters, with their distributions are discussed in relation to pharyngealization.

Other features of gemination and assimilation, however, are also discussed briefly. Rules of stress are specified. This description of the phonology of TA is in no way exhaustive, but serves to give an introduction to the sound system of TA. A longer study along this line will be necessary to give a complete picture of the phonology of TA, especially in the case of its syllable structure, the distribution and the limitations, for example, which types of syllables occur where. In the case of the clusters, a detailed analysis will show how the consonants operate within and across the syllable boundary.

1.4 Consonants

/b/	voiced bilabial stop /ba:b/ 'door'
/t/	voiceless denti-alveolar stop /ta:b/ 'he repented'
/T/	voiceless denti-alveolar pharyngealized stop /Ta:b/ 'it cooked'
/d/	voiced denti-alveolar stop /damm/ 'blood'
/D/	voiced denti-alveolar pharyngealized stop /Damm/ 'he tidied up'
/k/	voiceless velar stop /kalb/ 'dog'
/g/	voiced velar stop /galb/ 'heart'

/q/	voiceless uvular stop /qi:ma/ 'value'
/ʔ/	glottal stop /muʔmin/ 'believer'
/m/	voiced bilabial nasal /mo:ʒ/ 'waves'
/n/	voiced denti-alveolar nasal /na:s/ 'people'
/l/	voiced alveolar lateral /walla/ 'he returned'
/ɭ/	voiced alveolar pharyngealized lateral /waɭɭa/ 'God'
/r/	voiced alveolar tap or roll /ri:ɻ/ 'wind'
/f/	voiceless labio-dental fricative /famm/ 'mouth'
/s/	voiceless alveolar fricative /se:f/ 'sword'
/S/	voiceless alveolar pharyngealized fricative /Se:f/ 'summer'
/z/	voiced alveolar fricative /ze:t/ 'oil'
/Z/	voiced alveolar pharyngealized fricative /Zo:z/ 'two'
/ʃ/	voiceless palato-alveolar fricative /ʃe:n/ 'ugly'
/ʒ/	voiced palato-alveolar fricative /ʒa:f/ 'dry'
/χ/	voiceless uvular fricative /χe:r/ 'goodness'

/g/	voiced uvular fricative /ge:m/ 'clouds'
/ħ/	voiceless pharyngeal fricative /ħo:ʕ/ 'house'
/ʒ/	voiced pharyngeal fricative /ʒo:m/ 'swimming'
/h/	glottal fricative /hla:l/ 'moon'
/w/	voiced labiovelar approximant /we:n/ 'where'
/y/	voiced palatal approximant /ʕayy/ 'nothing'

Stops

The voiceless bilabial stop, /p/, occurs in loan words only. It is generally replaced by /b/, even by literate people, e.g., 'Pepsi' becomes /bibsi/.

The voiceless uvular stop, /q/, only occurs in loan words from Classical Arabic. As a result, it is mainly found in the speech of the literate, e.g., /raqi:q/ 'delicate', /qurʔa:n/ 'Koran', or words from the Koran. /g/ is generally used instead, except in the cases mentioned above.

The glottal stop /ʔ/, occurs in word-initial position, e.g., /ʔa:mis/ 'yesterday'. In word-medial position, even in words from Classical Arabic, it is often replaced by a long vowel or approximant, e.g., /mu:min/ for /muʔmin/

'believer', /ma:yil/ for /ma:ʔil/ 'leading'.

The sequence /tʔ/ in a word like /tʔa:nis/, renders it as a weak ejective [tʰ] .

A stop may have a nasal release when it precedes a nasal /m/ or /n/, e.g., /bna:ya/ 'building', /kma:m/ 'sleeves', /Tna:ʒ/ 'twelve'.

Final stops can be released or unreleased in free variation.

Voiceless non-pharyngealized stops can be aspirated, voiced stops can be devoiced in word-initial and final position.

A stop may have a front or back allophone, depending on the adjacent sounds.

Fricatives

The glottal fricative, /h/, occurs in syllable initial, medial and final position. Commonly, it is lost in word final position, e.g., /fi:h/ 'there is'. Intervocally, it is rendered as [ɦ] in /ba:hi/ 'good'.

/h/ has the effect of devoicing the following /l/ as in /hla:l/.

/v/ occurs in loan words from Italian. It is heard in the speech of both literate and illiterate people, e.g., /vazzo/ 'vase'. However, there are cases where /v/ is replaced by /w/ in the speech of the illiterate, e.g., /wi:lla/ 'villa'. Words which contain /v/ are always avoided in formal speech, and are replaced by words from Classical Arabic, e.g., /zahriyya/ for 'vase' instead of the common word /vazzo/.

When /z/ is preceded by /t/, /t/ becomes voiced and the sequence is rendered as an affricate [dz] in words like /tzi:b/ 'she brings/gives birth'.

Nasals

/n/ becomes [ŋ] when it occurs adjacent to the velars /k/, /g/ and the uvular /q/ in such words as /ngu:l/ 'we say', /nku:n/ 'we are', /nqa:wim/ 'we struggle'.

Laterals

/l/ is more frequent in occurrence than the pharyngealized counterpart /L/. (See chapter 6).

It may be devoiced when a voiceless stop or fricative precedes it in a stressed syllable, in words like /Xla:l/ 'safety pin', /kla:m/ 'speech'. This is more obvious with

some voiceless stops than others and more so in a stressed word-initial position.

Tap

This consonant in TA is either a tap or a roll, depending on its position in the word and whether it is geminated or not. It can be devoiced in certain cases, for example, in a final position in /Xe:r/.

Approximants

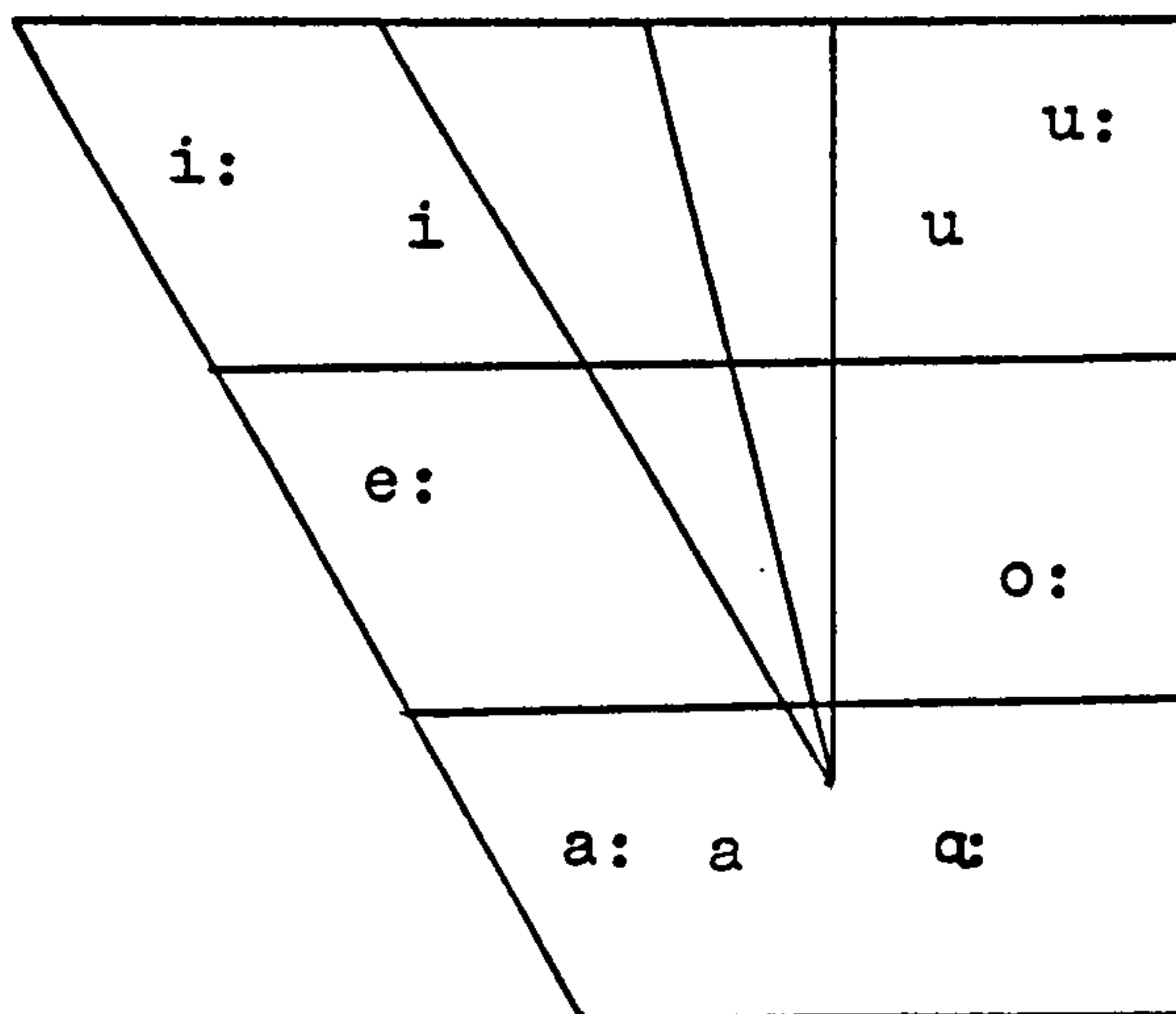
The approximants /w/ and /y/ may occur initially and finally in a syllable, /ward/ 'roses', /zre:w/ 'puppy', /yo:m/ 'day', /sɔy/ 'nothing'.

In final position, /w/ and /y/ only occur preceded by a vowel. They can occur before or after another consonant, e.g., /wsa33/ 'width', /ymi:n/ 'right', /Twi:l/ 'long/tall', /sya:sa/ 'policy'.

1.5 Vowels

There are nine vowel phonemes in TA. /i/, /a/ and /u/ are short. /i:/, /e:/, /a:/, /ɑ:/, /o:/ and /u:/ are long. Though the analysis is articulatorily and auditorily based, careful attention has been given to factors of consonantal environment and syllabic structure. The most important consonantal environments have been specified.

Vowels in TA occur in syllable medial and final position.



/a/ An open somewhat centralized vowel with neutral lip position. It is realised as [a̠] in the context of all consonants, except the uvulars and the pharyngealized consonants. Examples:

/damm/	'blood'
/sabb/	'he swore'
/ʒamm/	'uncle'
/ʁall/	'solution'

It is realised as [ɑ̠] in the context of uvulars and pharyngealized consonants. Examples:

/ʁall/	'vinegar'
/Si:ga/	'jewellery'

and in the context of /r/

/ʒizra/	'tree'
---------	--------

or

$$\begin{bmatrix} a \\ u \end{bmatrix} + \begin{bmatrix} r \\ \text{labiodental} \\ \text{velar} \end{bmatrix} + \text{labiodental}$$

/sarfa/ 'his honour'

/ʒurfa/ 'he knew him'

/ʁukka/ 'tin'

or

$$\begin{bmatrix} a \\ u \end{bmatrix} + \begin{bmatrix} r \\ \text{bilabial} \\ \text{velar} \end{bmatrix} + \text{bilabial}$$

/sarba/ 'soup'

/ʒurma/ 'heap'

or

$$\begin{bmatrix} a \\ u \end{bmatrix} + \begin{bmatrix} r \\ \text{velar} \end{bmatrix} + \text{velar}$$

/ʁarka/ 'movement'

/rugba/ 'thinness'

/a:/ An open somewhat centralized vowel with neutral lip position. It is realised as [a̠] in the context of all consonants except the pharyngealized. Examples:

/da:r/	'he did'
/ma:r/	'common'
/ba:n/	'appeared'
/ga:l/	'he said'
/ʒa:l/	'good'
/ʎa:l/	'condition'
/ʎa:r/	'puzzled' (m. sg.)

It is realised as [a̠̣] in the context of uvulars and pharyngealized consonants. Examples:

/Da:r/	'harmful'
/Ta:b/	'it cooked'
/Sa:m/	'he fasted'

/ɑ:/ An open centralized vowel with neutral lip position. Its frequency of occurrence is far less than the other vowels. Examples:

/dɑ:r/	'room'
/mɑ:r/	'passing'
/ʎɑ:r/	'hot'

/ʔama:n/	'a word of appreciation'
/la:mba/	'lamp'

/i/ A close front somewhat centralized vowel with neutral lip position. It is realised as [i̠] in the context of all consonants except the pharyngealized consonants. Examples:

/sinn/	'tooth'
/ɲiss/	'sound'
/Xinba/	'robbery'

It is realised as [ɘ] in the context of pharyngealized consonants. Examples:

/Siɲi/	'hygienic'
/Diffa/	'bank'

/i:/ A close front somewhat centralized spread vowel. It is realised as [i:] in the context of all consonants except the pharyngealized consonants. Examples:

/di:b/	'wolf'
/gi:m/	'pick (imp. m. sg.)'
/ʒi:d/	'feast'
/ri:ɲ/	'wind'

/si:X/	'skewer'
/gi:b/	'be absent (m. sg.)'

It is realised as [i̠:] in the context of the pharyngealized consonants. Examples:

/bi:D/	'white (pl.)'
/Ti:n/	'mud'

/e:/ A half-close front somewhat centralized vowel with spread lips. It is realised as [e̠:] in the context of all consonants except the pharyngealized consonants.

Examples:

/se:f/	'sword'
/be:n/	'between'
/le:l/	'night'
/Xe:l/	'horses'
/ge:m/	'clouds'
/ʒe:n/	'eye/
/ʁe:l/	'strength/

It is realised as [ɛ̠] in the context of the pharyngealized consonants. Examples:

/Se:f/	'summer'
/Te:r/	'bird'

/o:/ A half-close back to central vowel with slight lip-rounding. It is realised as [ɔ̞:] in the context of all consonants except the uvulars, pharyngeals and pharyngealized consonants. Examples:

/so:m/	'price'
/yo:m/	'day'
/do:r/	'turn'
/fo:z/	'group'

It is realised as [ɔ̞:] in the context of uvular, pharyngeal and pharyngealized consonants. Examples:

/So:m/	'fasting'
/To:r/	'group'
/no:ʒ/	'type'
/xo:ʒ/	'house'
/xo:f/	'fear'

/u/ A somewhat close back to central vowel with neutral lip position. It is realised as [u̞] in the context of all consonants except the uvulars, pharyngeals and pharyngealized consonants. Examples:

/murr/	'bitter'
/dull/	'degradation'
/kumm/	'sleeve'

It is realised as [u̟] in the context of uvulars, pharyngeals and pharyngealized consonants. Examples:

/Subb/	'pour (imp. masc. sg.)'
/Dull/	'shade/shadow'
/ħubb/	'love'
/gull/	'anger'
/Xuʕʕ/	'enter (imp. m. sg.)'

/u:/ A close back somewhat centralized rounded vowel.

It is realised as [u̟:] in the context of all consonants except the uvulars, pharyngeals and pharyngealized consonants.

Examples:

/tu:b/	'repent (imp. masc sg.)'
/su:r/	'fence'
/ku:l/	'eat (imp. m. sg.)'

It is realised as [u̟:] in the context of uvulars, pharyngeals and pharyngealized consonants. Examples:

/Tu:b/	'bricks'
/Su:ra/	'picture'
/Du:g/	'taste (imp. m. sg.)'
/gu:l/	'ghost'
/ʒu:d/	'stick'

/Xu:d/ 'take (imp. m. sg.)'

/ɰu:s/ 'moving around'

Vowels in TA occur in stressed and unstressed syllables whether they are short or long.

/i:/, /e:/, /a:/ and /u:/ occur in word medial and final position. However, they become short in word final position in rapid speech.

/o:/ does not occur in word final position, but it occurs in syllable-final position - /ro:ɣin/ 'window', /do:ra/ 'turn'.

/i/, /i:/ and /o:/ do not occur followed by /w/ or /y/ in a word final position.

Pharyngealized consonants have the effect of lowering the close vowels and retracting the open vowels whether they precede or follow the other consonants. Their effect extends to all the sounds, consonants and vowels in the syllable and in some cases across syllable boundary. Uvulars, on the other hand, although they have a similar effect to that of pharyngealized consonants, their influence is restricted to the adjacent open vowels only, whether preceding or following. They have no influence on the other vowels.

1.6. Syllable structure

Stetson (1951:171), states "The syllable is one in the sense that it consists essentially of a single chest pulse, usually made audible by the vocal folds, which may be started or stopped by a chest movement or by a consonant movement. These auxiliary articulatory movements cannot be considered independent, because their essential function is to delimit the chest pulse, and their characteristics depend on that function". Following Stetson, Abercrombie (1967), stresses the chest pulse as the basis of the syllable with the vowel as the "nucleus or central part of the syllable" and the consonant as "marginal part, associated with the beginning and ending of the movement of air engendered by the chest-pulse". A syllable then, according to Stetson and Abercrombie, has three phases: a) the starting phase or the release; b) the vowel and c) the arresting phase. Both the first and third phases have the consonants as their elements. The shortest duration of the three phases are of the releasing consonants (Abercrombie, 1967).

A syllable can be closed or open, depending on the last element of the syllable. It is closed, if it is arrested by a consonant. An open syllable is one which has no arresting phase. Syllables in TA can be open or closed. An open syllable ends with a vowel. It is short if it contains a

short vowel, and long if it contains a long vowel. A closed syllable ends with a consonant, a consonant cluster or a geminate cluster. An utterance may or may not begin with a consonant, and it may or may not end with a consonant. TA has the following types of syllable, where C stands for consonant and V stands for vowel. Syllables with short vowels:

VCC		in /abb/ 'father'
CV	/---ma/	in /zaʒma/ 'maybe'
CVC	/ʒar--/	in /ʒarba/ 'soup'
CVCC		in /bint-/ 'a girl'
		in /sadd/ 'dam'
CCV	/tla--/	in /tlati:n/ 'thirty'
CCVC	/ʒbaħ-/	in /ʒbaħna:h/ 'we saw him'
CCVCC		in /ʒraft/ 'I knew'
		in /ʒrabb/ 'Arabs'
CCCVC		in /nftaħ/ 'it opened'

Syllables with long vowels:

V:C		in /a:ʒ/ 'how'
CV:		in /la:/ 'no'
CV:CC		in /ʒa:dd/ 'exception'
CCV:		in /gʔa:/ 'cover'
CCV:C		in /kta:b/ 'a book'
CCCV:C		in /stra:ħ/ 'he rested'

Final long open syllables become short in rapid speech.

The short vowel [i] is invariably inserted between the last two consonants of the closed syllables CVCC, and CCVCC. /sʌm[i]s/ 'sun' and /ʒmal[i]t/ 'I did'.

The patterns of the syllable structure in TA can then be best represented in this formula

$$\begin{array}{c} \text{C} \text{---} \text{---} \text{---} \\ 1 \quad 3 \end{array} \quad \text{V}(:) \quad \begin{array}{c} \text{C} \text{---} \text{---} \text{---} \\ 0 \quad 2 \end{array} .$$

1.7 Consonant combinations

Unlike Classical Arabic which does not permit syllable initial consonant clusters, syllables in (TA) begin with one consonant or more. This may be a result of the influence of Berber on Arabic, where for the former a cluster of two or more consonants is permissible in word initial position.

A combination of more than one consonant occurring in the same syllable is called a 'cluster', but a 'sequence' if these consonants occur in two consecutive syllables (Pulgram, 1965:76).

Consonant clusters occur in word initial, medial and final position. The initial position clusters of more than two consonants are not frequent. In medial position, combinations are more often sequences than clusters, as

they commonly occur across syllable boundary.

Consonant combinations are discussed here only in relation to pharyngealization. A study of the phonology of TA can deal with this feature in detail, but the scope of this thesis does not permit a detailed study of this nature. From a separate study undertaken to establish what combinations of consonants are permissible in TA in relation to pharyngealization, it was found that two identical consonants may occur in the same sequence, e.g., /kaħħa/ 'a cough' which is an example of gemination.

In general, the further apart are the places of articulation of the consonants, the more permissible the combination is.

The pharyngeals /ħ/ and /ʕ/ do not occur in combination with each other. That is, there are no combinations of /ħʕ/ or /ʕħ/. /ħ/ and /ʕ/ do not occur in combinations with the glottals /h/ and /ʔ/, or the uvulars /x/ and /g/. That is, there are no combinations of /ħh/, /hħ/, /ħʔ/, /ʔħ/, /ʕh/, /hʕ/, /ʕʔ/, /ʔʕ/, /ʕx/, /xħ/, /xʕ/, /ʕx/, /għ/, /ħg/, /gʕ/, /ʕg/.

/ħ/ and /ʕ/ occur with the uvular /q/ in words from Classical Arabic /ʔaħqa:d/ 'envies' /ʔaʕqa:b/ 'remains'. The syllabic structure of some of these words may be modified to that of the dialect, e.g., /ħqu:q/ 'rights', /ʕqad/ (/iztima:ʕ/) 'he held a meeting', which in Classical Arabic are /ħuqu:q/ and /ʕaqad/.

Combinations of the pharyngeals /ħ/ and /ʕ/ with the pharyngealized consonants, the velars /k/ and /g/ are permissible as well as the rest of the consonants.

The uvulars /X/, /g/ and /q/ do not occur in combinations with each other. That is, there are no combinations of /Xg/, /gX/, /Xq/, /qX/, /gq/, /qg/. The uvulars /X/ and /g/ do not occur in combinations with the pharyngeals /ħ/ and /ʕ/. That is, there are no combinations of /Xħ/, /Xʕ/ or /għ/, /gʕ/. /q/ occurs with the pharyngeals /ħ/ and /ʕ/ in these words: /ʔuqħuwa:n/ 'poppies', /maqʕid/ 'desk'. Combinations of the uvulars /X/ and /g/ with the glottals /h/ and /ʔ/ and the velars /k/ and /g/ are not permissible. That is, there are no combinations of /Xh/, /hX/, /Xʔ/, /ʔX/, /gh/, /hg/, /gʔ/, /ʔg/, /Xk/, /kX/, /Xg/, /gX/, /gk/, /kg/, /gg/, /gg/. .

The uvulars /X/, /g/ and /q/ may occur with the pharyngealized consonants. They occur freely with the rest of the consonants.

The pharyngealized consonants /T, D, S, Z, L/ occur in combinations with each other, except /S/ and /Z/ do not occur together and their occurrence in combination with the velars /k/ and /g/ is restricted. The pharyngealized consonants may occur with the uvulars /X/ and /g/. Combinations of the pharyngealized consonants with the uvular /q/ only occur in these words /qSu:r/ 'palaces', which is originally /quSu:r/ in Classical Arabic; or /ʔaqTa:b/ 'poles', /ʔaqSa/

'further'. The distribution of /Z/ and /L/ is very restricted, therefore, combinations of /Z/ and /q/ or /Z/ and /L/ cannot be found. Combinations of the pharyngealized consonants with the pharyngeals and the glottals are permissible.

In general, consonants which are not permissible in the same cluster, are permissible in morphological combinations.

1.8 Gemination

Gemination is regarded as the prolongation and the increase of tenseness 'tashdi:d' of the consonantal element in an utterance. Geminated consonants may be called long or doubled consonants. "Doubled consonants are pronounced longer than their single counterparts and with greater tenseness of articulation", (Mitchell, 1975). The tenseness is a consequence of the articulators having to hold the same position for a longer period than for a single sound.

Gemination of the consonants may occur initially medially and finally. In a final position, geminated consonants occur after a stressed syllable.

Phonologically, geminated consonants are considered to be two identical consonants and are represented by two consonants, e.g., /mXadda/ 'pillow'.

On the phonetic level, it is not possible to separate between the two identical consonants. Hegedus (1959, cited in Lehiste, 1973), in his acoustic study of single and geminated consonants within word boundaries in Hungarian, found no evidence for rearticulation of the geminated consonants.

Delattre (1981), in his study to determine the acoustic, articulatory and auditory correlates for the perception of consonant gemination within and across word boundary in English, German, Spanish and French, found that consonant duration is a major attribute of gemination.

In syllable initial or word initial position, geminated consonants are frequently preceded by the anaptyctic vowel[i]. Though clusters of two or more consonants are permissible in this position, they generally consist of two single consonants or more, that is, non-identical consonants.

Geminated consonants can be preceded either by a long or short vowel, /ma:dda/ 'substance', /ʒidda/ 'tools'. The doubling of the consonant does not shorten the duration of the preceding vowel to any great extent.

Al-Jazary, however, in his experimental study of vowel duration in Iraqi spoken Arabic (1981), found statistically that vowels are longer before single consonants than before geminate consonants, irrespective of whether the vowel is followed by a voiced or voiceless stop, voiceless 'emphatic'

stop, or voiceless fricative stop in stressed or unstressed syllable, and a consonant cluster of identical or different consonants is usually preceded by a relatively shorter vowel than that preceding a single consonant. He is in agreement with Delattre (1962) and (1971), who found that a vowel is shorter before a consonant cluster or a geminate consonant than before a single consonant.

The problem of gemination of final consonants has been discussed by Mitchell (1960), Blanc (1952), Harrell (1957) and Ahmed (1979). Harrell prefers to use a single consonant in a final position to avoid the confusion that stems from phonological and morphological alternation. Mitchell, however, uses double consonants to distinguish between words like /sikit/ 'he was silent', /muʒtamid/ 'dependent' and /sikitt/ 'I became silent', and /mustaʒidd/ 'ready', where in the second pair, he says, there are differences of vowel length and consonant length and a firmer contact of the tongue.

Because gemination is common in TA, and at the same time to avoid the confusion which may arise from having one symbol in a final position, which may render a different meaning, the author chooses in this thesis to denote gemination of final consonants by the doubling of the consonant.

1.9 Assimilation

Assimilation is defined as "... the process of replacing a sound by another sound under the influence of a third sound which is near to it in the word or sentence". Jones (1969:217-18). Or, as "A feature of one sound is extended to another". Borden and Harris (1980:127).

There are two kinds of assimilation, depending on the place of the assimilated sound. Progressive, if the assimilated sound is influenced by a preceding sound. Regressive, if the assimilated sound is influenced by a following sound.

Assimilation is a feature that is very common in casual rapid speech, "The result of the assimilation is to reduce the number, or the extent, of the movements and adjustments which the speech-producing organs have to perform in the transition from one word to the next". Abercrombie (1967:135). He adds that "Assimilations save effort by means of three different sorts or changes in the sequence of speech producing movement.

- (1) those involving the state of the glottis;
- (2) those involving velic action;
- (3) those involving movement of the articulators".

Griffini (1913), describes assimilation in the Libyan Arabic of Tripoli as numerous and frequent. He lists the assimilated sounds as follows:

dt	---	tt	h _h	ts	---	ss
td	---	dd	h _h	tš	---	ss
tt	}	tt	ħh	tš	---	ts/ss
tt			h _h	tz	---	dz/žz
dt			ħh	tž	---	dž/žž
td	---	dd	h _h	nb	---	mb
nl	---	ll	h _h	nf	---	mf
nr	}	rr	h _h	ng	---	ñg
lr			h _h	nt	---	nK
ln	---	nn	ħh	nh	---	ñh
kg	}	gg	ħh	nš	---	ñš
gk			sd	ns	---	ñs
			s	---	zd	

Unfortunately, Griffini does not give any examples of words of the assimilated consonants. Some of the listed consonants seem to occur only across word boundary.

The following are the most common occurrences of assimilated consonants in TA.

Regressive assimilation:

Assimilation of voiceless to voiced:

t	d	→	dd	in	/mitdawwir/	'round'
t	D	→	DD	in	/tDu:g/	'she tastes'
t	z	→	dz	in	/tzi:d/	'she adds'
t	g	→	dg	in	/tgu:l/	'she says'
t	ʒ	→	dʒ	in	/tʒi:b/	'you bring'
k	d	→	gd	in	/tikdib/	'she lies'
ʃ	b	→	ʒb	in	/yiʃbaʒ/	'he has eaten enough'
ʃ	d	→	ʒd	in	/ʃdu:g/	'cheeks'

Assimilation of voiced to voiceless:

d	t	→	tt	in	/gʒadt/	'I stayed'
---	---	---	----	----	---------	------------

Assimilation of point of articulation:

n	b	→	mb	in	/nbu:la/	'balloon'
n	f	→	mf	in	/nfass/	'breath'

Other examples of regressive assimilation:

l	t	→	tt	in	/ʒe:lt/	'family'
l	n	→	nn	in	/ʒmalna/	'we did'

n l	----→	ll	in	/yinla:m/	'to be blamed
n r	----→	rr	in	/nrawwiŋ/	'I go back'
s ʒ	----→	ʒʒ	in	/siʒill/	'file'
ʒ s	----→	ss	in	/ʒams/	'sun'
ʒ z	----→	zz	in	/ʒo:z/	'nuts'

Progressive assimilation:

z ʒ	----→	zz	in	/zo:ʒ/	'husband'
ʒ h	----→	ŋŋ	in	/ba:ʒha/	'he sold it (her)'
ŋ h	----→	ŋŋ	in	/naŋŋha/	'he removed it'

1.10 Stress

The placing of stress within a word is predicted from its syllable structure.

1. Monosyllabic words:

A monosyllabic word is always stressed, whether the vowel is long or short.

/ˈta:b/	'he repented'
/ˈsadd/	'dam'
/ˈgre:/	'he read'

2. Polysyllabic words:

In polysyllabic words, the rules are as follows:

- a) Stress falls on the final syllable if it is heavy, that is, if it contains a long vowel or is closed by a consonant cluster or a geminate cluster.

/ga:ʒdi:n/	'they are present'
/ʔaʀagg/	'finer'
/kallimt/	'I spoke'

- b) Otherwise stress falls on the penultimate syllable if it is heavy.

/darbu:ka/	'drum'
/maʒmil/	'factory'

- c) Stress falls on the antepenultimate syllable if the penultimate syllable is not heavy

/ʒarika/	'company'
/sayya:ritna/	'our car'

CHAPTER II

Structures and Muscles

2.I: Introduction

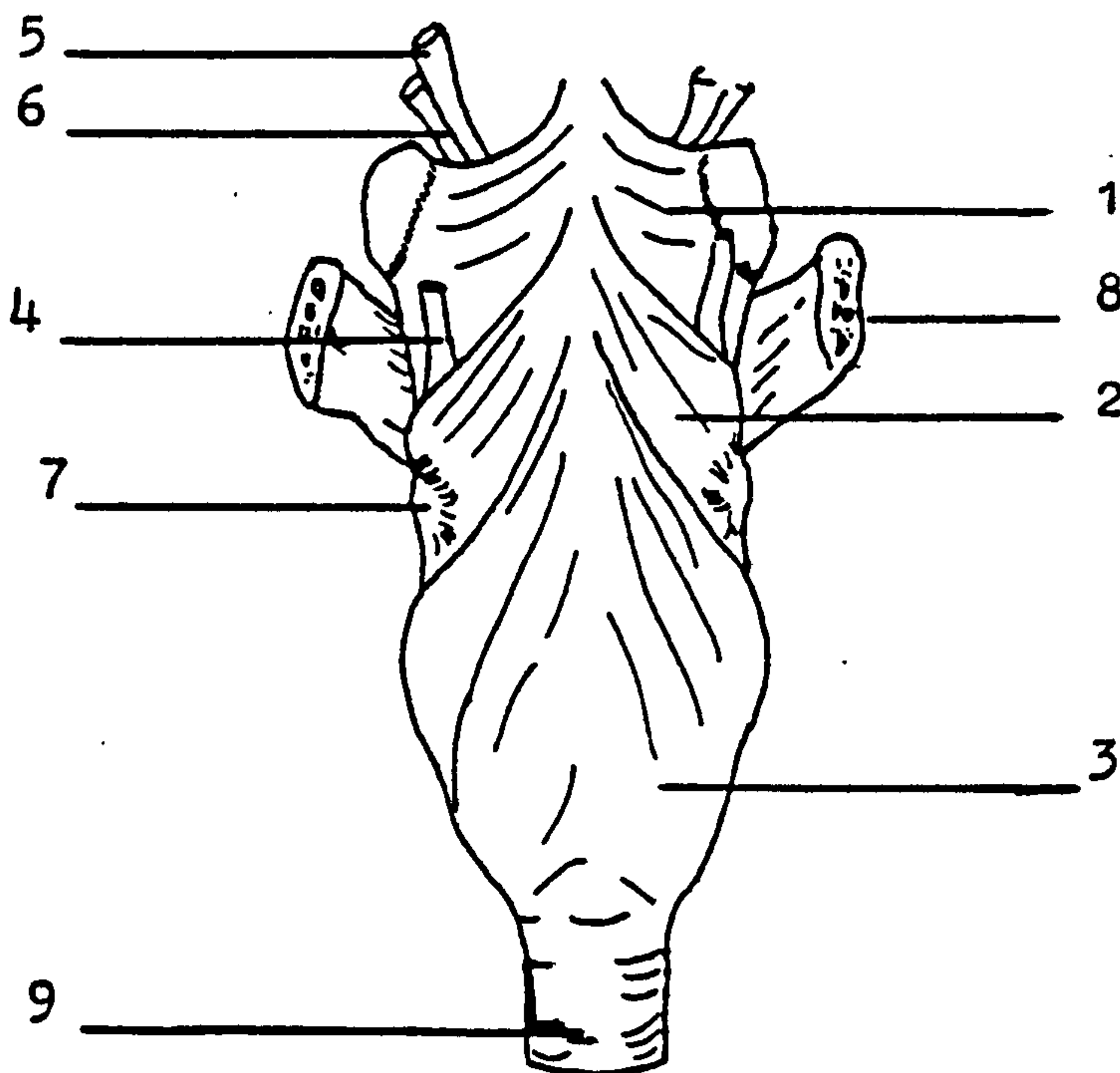
In this chapter, the most important structures and muscles that are generally accepted as taking part in the production of pharyngeals, uvulars and pharyngealized sounds are described. No dissection was carried out for this thesis because a) lack of practical experience may well have produced wrong or misleading conclusions, and b) because the functional anatomy of this area of the body is well established, further dissection and further investigation would seem only to be warranted where there are discrepancies between published opinions and personal observation. The main aim is to describe in as great detail as possible the actual final physiological, acoustic and aerodynamic result of muscle action rather than the muscle action itself. The information in this chapter is, therefore, entirely based on other people's work. A number of works on the anatomy and physiology of the speech organs were consulted. Most of the information was obtained from Cunningham, (1953), Hardcastle (1976), Kaplan (1971) and Laver (1980). Though they all agree on the location of the structures and muscles, they disagree in a number of cases where the action of certain muscles is concerned, especially

in those cases where they try to relate the action of a certain muscle to an act of speech. Their opinions are even more speculative when they attempt to relate the action of the particular muscles to the feature of pharyngealization. Only Laver (1980), and McCurtain (1982), relate the action of these muscles to the production of pharyngeals, uvulars or pharyngealized sounds. McCurtain, for instance, suggests that the most important muscles in the production of the 'emphatic' sounds are the superior pharyngeal constrictor and the styloglossus muscles, and that the contraction of the buccinator causes the cheeks to hollow, a gesture which she observed to occur for the 'emphatics'.

2.2: The Pharynx (see Figures 2.1. and 2.2.)

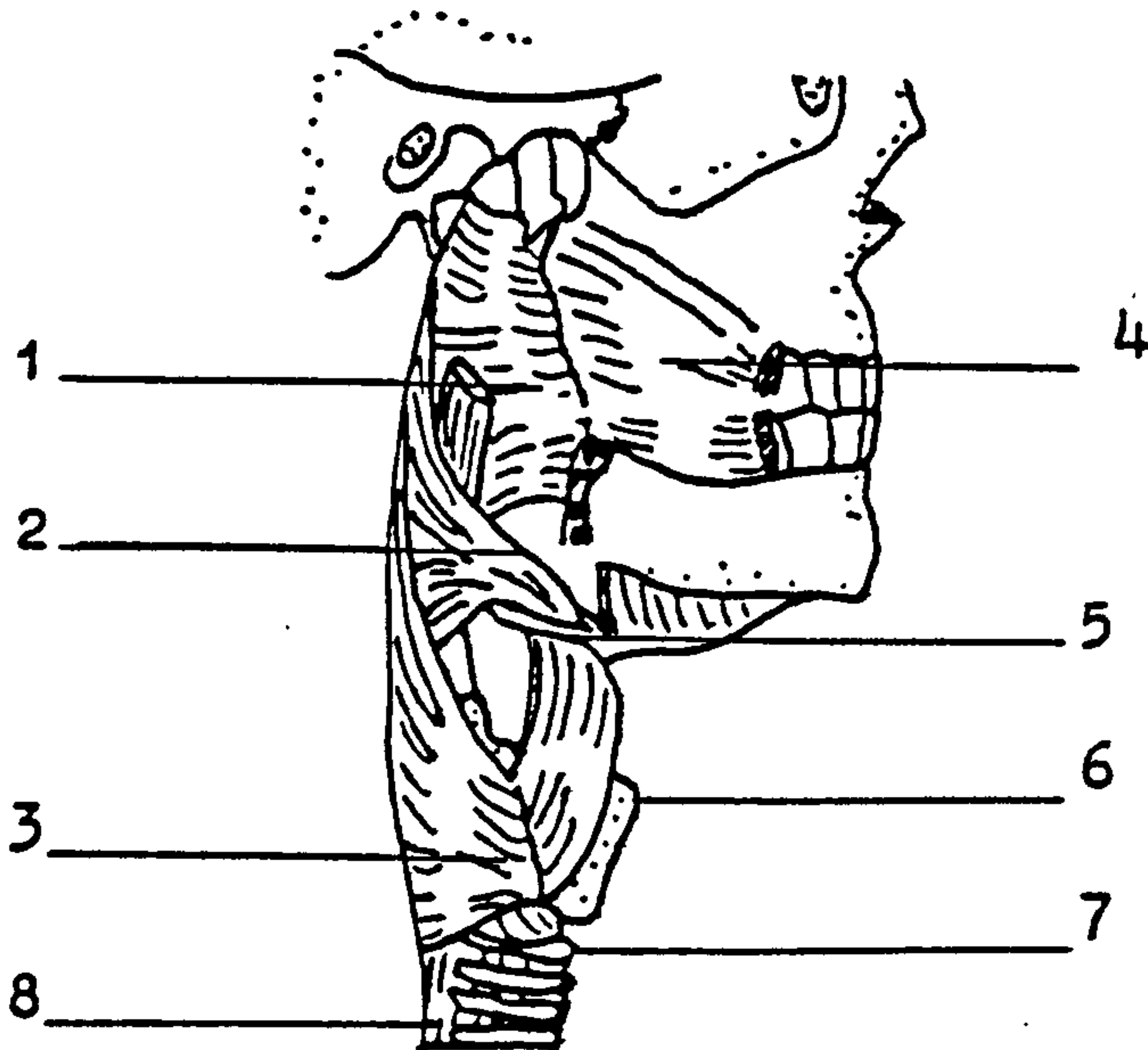
Zemlin (1964:225) cited in Laver (1980:59), describes the pharynx as "a cone shaped tube about 12 cm. in length and wider at the top than at the bottom. It is about 4 cm. wide at its extreme width superiorly and about 2 cm. from front to back. It narrows considerably until, at the level of the larynx in front and the sixth cervical vertebra behind, it is about 2.3 cm. wide. At its lowest extreme, the pharynx is continuous with the oesophagus, and at this level the front and back walls of the pharynx are in direct contact with one another and separate only to permit the passage of food into the oesophagus".

Figure 2.1 A posterior view of the most important muscles of the pharynx (from Kaplan 1960:322)



1. Superior constrictor muscle
2. Middle constrictor muscle
3. Inferior constrictor muscle
4. Stylopharyngeus muscle
5. Palatal levator muscle
6. Palatal tensor muscle
7. Greater horn of the hyoid bone
8. Mandible
9. Esophagus

Figure 2.2 A lateral view of the pharyngeal constrictors (from Kaplan 1971:323)



1. Superior constrictor
2. Middle constrictor
3. Inferior constrictor
4. Buccinator
5. Hyoid
6. Thyroid
7. Trachea
8. Esophagus

The pharynx is divided vertically into three sections: The nasopharynx, which "is a cube-shaped cavity just posterior to the nasal cavities and posterior to the level of the soft palate". (Kaplan, 1971:317). The nasal cavity is always open, that is, connected to the oropharynx, except during swallowing and in certain cases in speech when it is completely closed by the raising and retracting of the velum against the contracting back wall of the pharynx at the Passavant ridge.

The oropharynx: "... the oropharynx or mesopharynx, is the section directly below the nasopharynx and lies posterior to the mouth and tongue. It extends vertically from the soft palate and pharyngeal isthmus above, to the level of the hyoid bone or pharyngoepiglottic folds below. Its posterior wall is in relation to the bodies of the second, third, and fourth cervical vertebrae. Anteriorly, it communicates through the fauces with the mouth. Below this region, the anterior wall is formed by the root of the tongue". (Kaplan, 1971:319). The uvula and part of the epiglottis are the important structures in the oropharynx. The main place of articulation for the uvular, pharyngeals and pharyngealized sounds is at this part of the pharynx, mainly by the projection of the root of the tongue backwards to the pharynx. And by a constriction of the lateral walls of the pharynx.

The laryngopharynx: "The inferior subdivision, the laryngopharynx, decreases abruptly in width and becomes continuous with the esophagus at the level of the inferior border of the cricoid. Its anterior wall is formed partly by the posterior wall of the larynx, and it communicates with the larynx through the epiglottis. The aryepiglottic folds are its lateral boundaries, and the fifth and sixth cervical vertebrae are its posterior boundaries". (Kaplan, 1971:319).

The dimensions of the pharynx can be altered at different levels. At the oropharynx, the anterior posterior dimension decreases as a result of the retraction of the root of the tongue towards the back wall of the pharynx. At the nasopharynx, it can be altered by the velum (Hardcastle, 1976:125), or by the constriction of the faucal pillars. "The lateral dimension of the pharynx can also be raised, this time by the muscles of the pharynx itself, which have basically a sphincter function. Isotonic contraction of these sphincter muscles will narrow the pharynx and isometric contraction will serve to tense the wall of the pharynx". This affects the resonance of the sound, "giving it a metallic, strident quality", (Hardcastle, 1976:125).

The constriction of the pharynx is accomplished mainly by three sphincteric muscles. They are the superior constrictor, the middle constrictor and the inferior

constrictor, Figure 2.2. Other muscles also change the diameter of the pharynx vertically by drawing up the walls of the pharynx. These are the stylopharyngeus and salpingopharyngeus muscles.

"The muscles form much of the framework of the lateral and posterior walls of the pharynx. They are arranged in an outer and inner layer, which are not readily separable throughout. The outer layer is arranged circularly, and is comprised of three constrictor muscles. These muscles change the diameter of the tube. The inner layer is roughly longitudinal, and it includes the palato pharyngeus, salpingo pharyngeus, stylopharyngeus muscles, and other irregular muscle bundles. The inner muscles function in elevation, depression, expansion and contraction of the pharynx". (Kaplan, 1960:204). The constrictor muscles "form curved sheets which lie in the posterior wall and sides of the pharynx, and overlap each other from below upwards. They are inserted into a median fibrous raphe which descends in the posterior pharyngeal wall from the pharyngeal tubercle on the base of the skull". (Romanes, 1975).

The superior pharyngeal constrictor. This is a broad mass of fibres some of which originate at the root of the tongue. From the posterior vertical raphe, a thin sheet of muscles extends forward on each side. The fibres actually curve backwards and upwards (Kaplan, 1971), and

the constriction of this muscle helps to raise the velum, (Laver, 1980). Of the three constrictor muscles, the superior constrictor is the weakest, (Laver, 1980).

The middle pharyngeal constrictor. This is a fan-shaped muscle arising from the horns of the hyoid bone, whose fibres curve upwards and backwards. The uppermost fibres rise to cover the superior constrictor, the middle fibres run horizontally from the root of the tongue while the lower fibres run downwards and backwards beneath the inferior constrictor. It is this muscle which constricts the pharynx, (Kaplan, 1971, Hardcastle 1976, Laver 1980).

The inferior pharyngeal constrictor. This is considered the broadest and thickest of the three constrictors. It originates from the cricoid and thyroid cartilages and its fibres curve backwards and upwards to meet at the posterior midline pharyngeal raphe. The uppermost fibres rise upwards and overlap with the middle constrictor almost covering it. The lowest ones are horizontal. When the inferior pharyngeal constrictor contracts, it pulls the larynx upwards, but when the larynx is fixed by the infrahyoids, it has a sphincteric action resulting in the constriction of the laryngopharynx (Kaplan 1971, Hardcastle 1976, Zemlin cited in Laver 1980).

The stylopharyngeus. This muscle originates at the temporal bone and inserts in the constrictor musculature, the palatopharyngeus and the posterior edge of the thyroid cartilage. The stylopharyngeus as it contracts, elevates the larynx and pharynx, but if the larynx is fixed by the infrahyoids, it expands the pharynx laterally (Kaplan 1971, Zemlin cited in Laver 1980).

The salpingopharyngeus. This muscle originates from the Eustachian tube and extends vertically to meet the upper fibres of the palatopharyngeus muscle and the walls of the back pharynx. These muscles elevate the pharynx and constrict the upper part of the pharynx laterally. (Greene 1964, cited in Laver 1980), however, states that the stylopharyngeus and salpingopharyngeus muscles raise and narrow the lateral walls of the pharynx when they contract. In swallowing, the salpingopharyngeus, the stylopharyngeus and the palatopharyngeus along with other muscles elevate the pharynx to receive the bolus of food. After receiving the food, the constrictors cause the pharynx to descend and constrict. This action of elevation and constriction is reminiscent of that which occurs during the production of the pharyngeals (see Chapter IV). Hardcastle rejects the probability of rapid fluctuations in the lateral width of the pharynx due to the size and shape of the constrictor pharyngeal muscles. It was experimentally found that the lateral walls of the pharynx are capable of moving very

rapidly (see Chapter V). "The settings of the oropharynx furnish one of the best examples of the intricate interlocking of muscle systems, which affect, and are affected by, settings in various parts of the vocal tract and larynx. Laryngeal, velopharyngeal, tongue-body, tongue-root and hyoid-positioning settings all potentially interact with oropharyngeal settings". (Laver, 1980:59). Laver emphasises "the complex mutual interdependence of the muscle systems used to achieve particular settings".

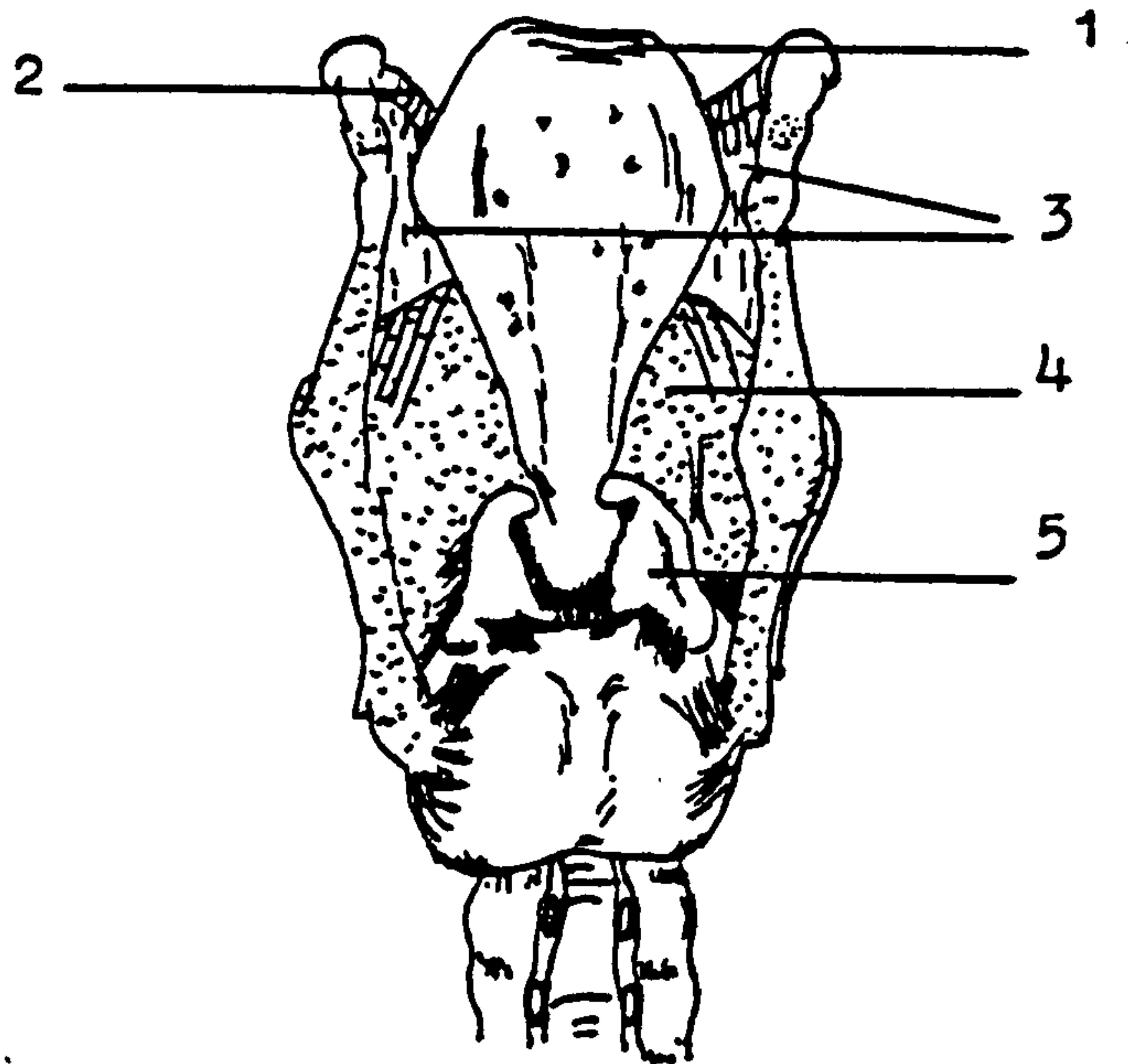
2.3: The Epiglottis, Figures 2.3. and 2.4.

"The epiglottis is a relatively large, leaf-shaped or spoon-shaped structure of cartilage and connective tissue". (Heffner, 1950:19). It is attached by ligaments to the base of the tongue, to the wall of the pharynx, to the hyoid bone and to the thyroid cartilage (Cunningham, 1953).

It has two surfaces; anterior or lingual of which the upper surface curls upwards. The degree of curling varies according to different articulations. The other is the posterior or laryngeal surface which is "concavo-convex in passing downward", (Kaplan, 1960:117).

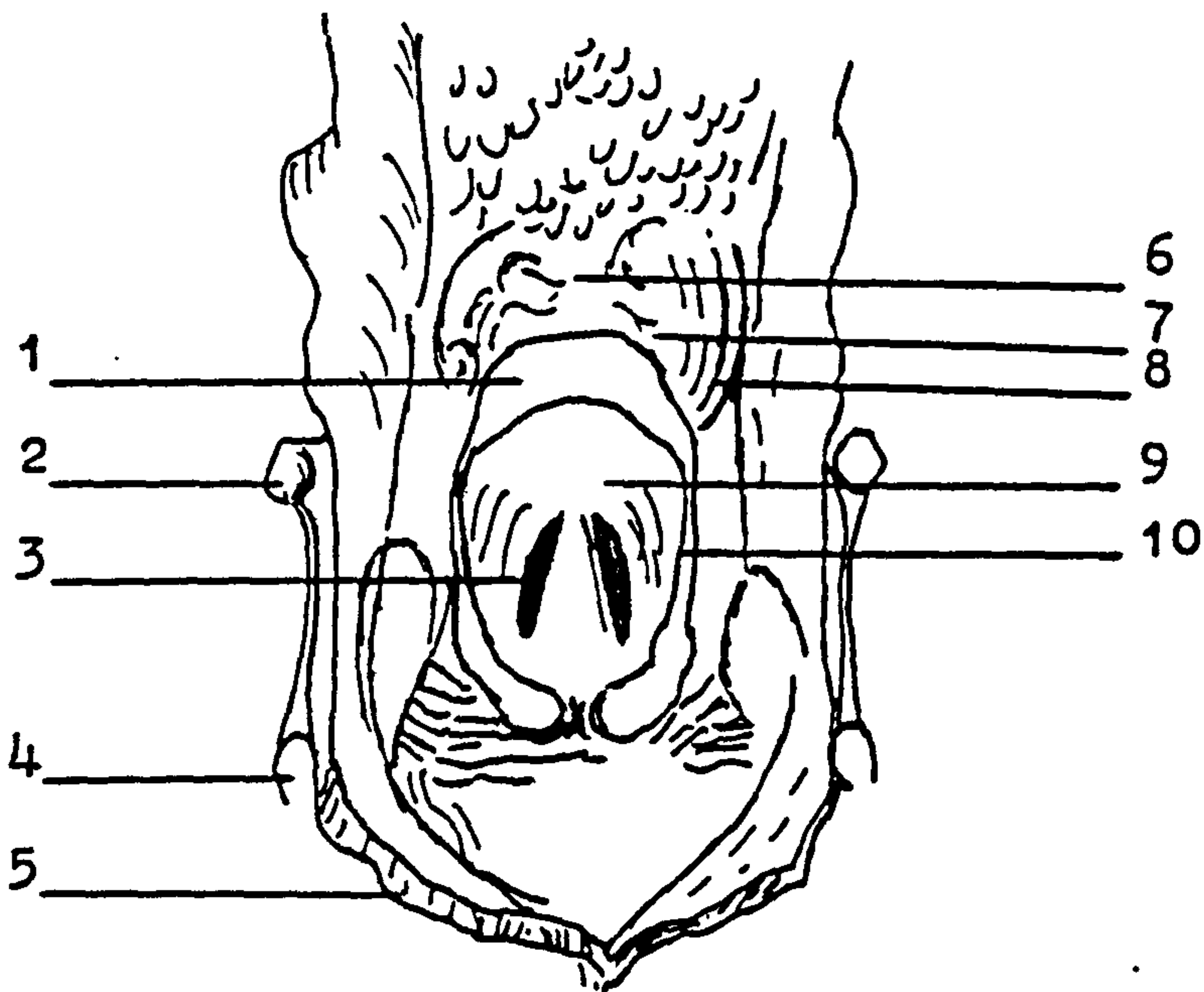
The glossoepiglottic fold extends from the anterior part to the root of the tongue. There is a depression called the vallecula that lies between the pharyngoepiglottic folds, the lateral margins of the epiglottis and the sides of the tongue. The epiglottis is attached to the arytenoid cartilages by the aryepiglottic folds.

Figure 2.3 A posterior view of the epiglottis in relation to cartilages of the larynx (from Kaplan 1960:117)



1. Epiglottis
2. Hyoid bone
3. Hyothyroid membrane
4. Thyroid cartilage
5. Arytenoid cartilage

Figure 2.4 A view from above of the epiglottis in relation to other structures in the pharynx and larynx (from Cunningham 1953:692)



1. Epiglottis
2. Hyoid bone
3. Vocal fold
4. Superior horn of thyroid
5. Posterior pharyngeal wall
6. Glossoepiglottic fold
7. Vallecula
8. Pharyngo-epiglottic fold
9. Tubercle of epiglottis
10. Ary-epiglottic fold

The anterior surface of the epiglottis has two attachments superiorly; one, the median glossoepiglottic fold to the base of the tongue and the other, the hypoepiglottic ligament to the upper border of the hyoid bone.

The thyroepiglottic ligament attaches the stem of the epiglottis to the thyroid cartilage (Cunningham, 1953). Above the upper part of the thyroepiglottic ligament lies a pad of fat.

In swallowing, the epiglottis bends backwards and covers the upper surface of the larynx, thus deflecting food away from the glottis into oesophagus. However, its removal does not have any serious consequences in swallowing, (Heffner, 1950:19, Kaplan, 1960:119).

There are no direct muscular attachments to the epiglottis, and it, therefore, moves only when pushed or pulled by neighbouring organs, notably the tongue and the hyoid bone (Heffner, 1950).

2.4: The hyoid bone, Figure 2.5.

It is a U-shaped bone with an anterior part or body and two lateral horns pointing to the back wall of the pharynx. It is suspended horizontally, just above the larynx and attached to the larynx, pharynx, tongue and jaw by muscles and ligaments. It has no direct attachment to any other bone. It is connected to the skull by the stylo-

hyoid ligament which raises the hyoid bone and draws it forward or backward. The hyoid bone also moves laterally; its horns can be tilted, i.e., one horn being higher than the other in some voice qualities (McCurtain, 1982).

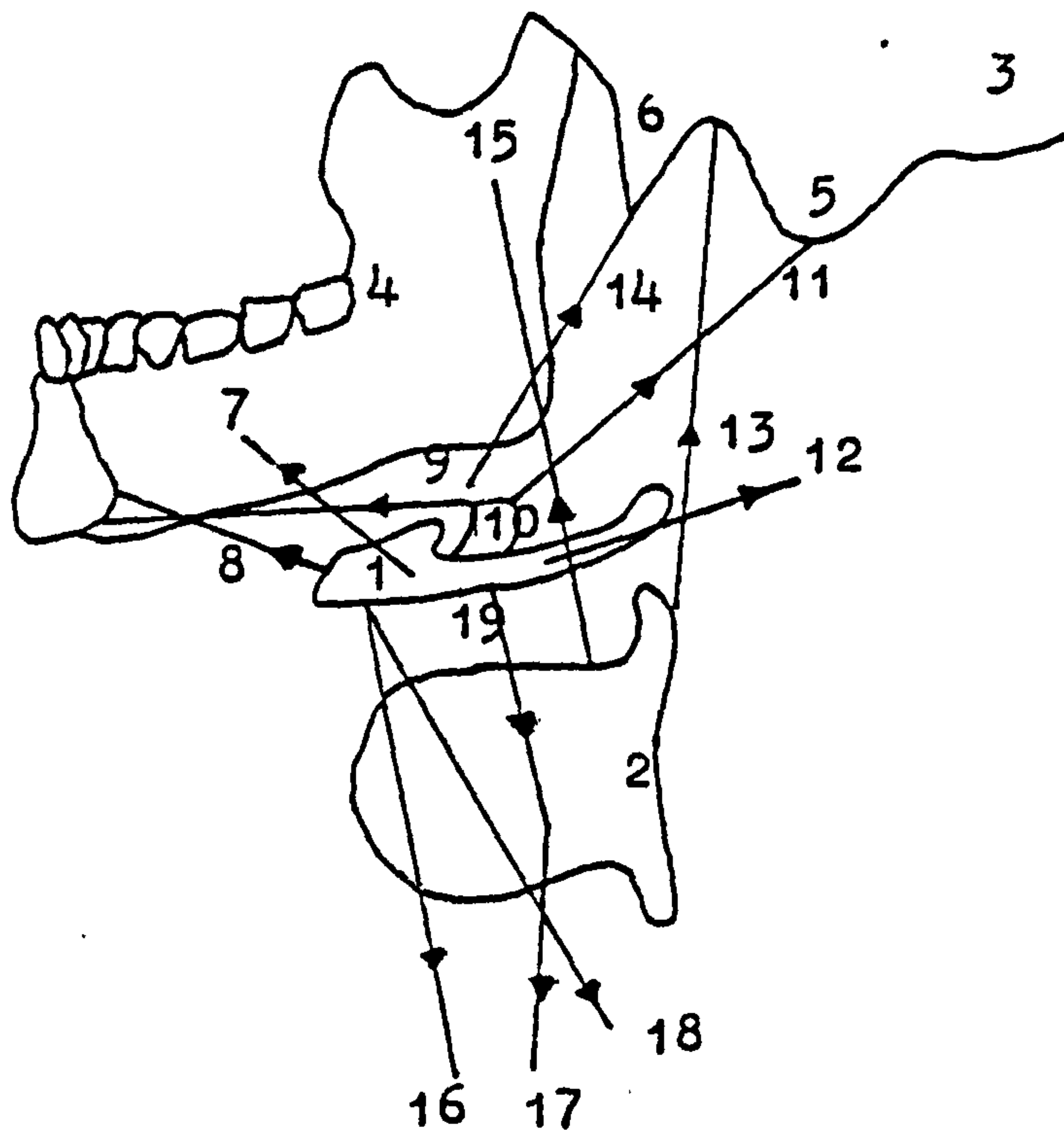
The middle pharyngeal constrictor and the inferior pharyngeal constrictor can raise the hyoid and the larynx and draw them towards the vertebrae (Heffner, 1950)

The hyoid bone and the larynx can be raised together forwards by the geniohyoid, genioglossus, mylohyoid and the anterior belly of the digastric muscle (Kaplan, 1960). The hyoid bone and the larynx can be raised and drawn backwards by the stylohyoid, palatopharyngeus and the middle pharyngeal constrictor (Van Riper and Irwin cited in Laver, 1980).

The hyoid bone may be lowered by the omohyoid, and the thyrohyoid muscles which also draw it backwards, (Kaplan, 1960).

The hyoid bone's muscular suspension with the muscular sling mechanisms of raising, lowering, backwards and forwards "having to be appropriately balanced for the accurate production of almost every single act of the vocal apparatus, makes the hyoid complex the prime example of mutually-influencing interaction of different muscular systems in speech". (Laver, 1980:26).

Figure 2.5 A schematic diagram (from Laver 1980:25) showing the action of the hyoid bone musculature in relation to other structures



1. Hyoid bone
2. Thyroid cartilage
3. Skull
4. Internal surface of lower jaw
5. Mastoid process
6. Styloid process
7. Mylohyoid muscle
8. Geniohyoid muscle
9. Anterior belly of the digastric muscle
10. Fascial sling
11. Posterior belly of the digastric muscle
12. Middle pharyngeal constrictor muscle
13. Stylopharyngeus muscle
14. Stylohyoid muscle
15. Palatopharyngeus muscle
16. Sternohyoid muscle
17. Sternothyroid muscle
18. Omohyoid muscle
19. Thyrohyoid muscle



Arnold, (1957:56), states that the removal of the hyoid bone has no apparent effects. Its function is mainly to insert and support the lingual and laryngeal muscles.

2.5: The Tongue, Figure 2.6.

The base of the tongue forms the anterior wall of the oral pharynx. The dorsum is the upper surface which lies below the hard and soft palate (Heffner, 1950).

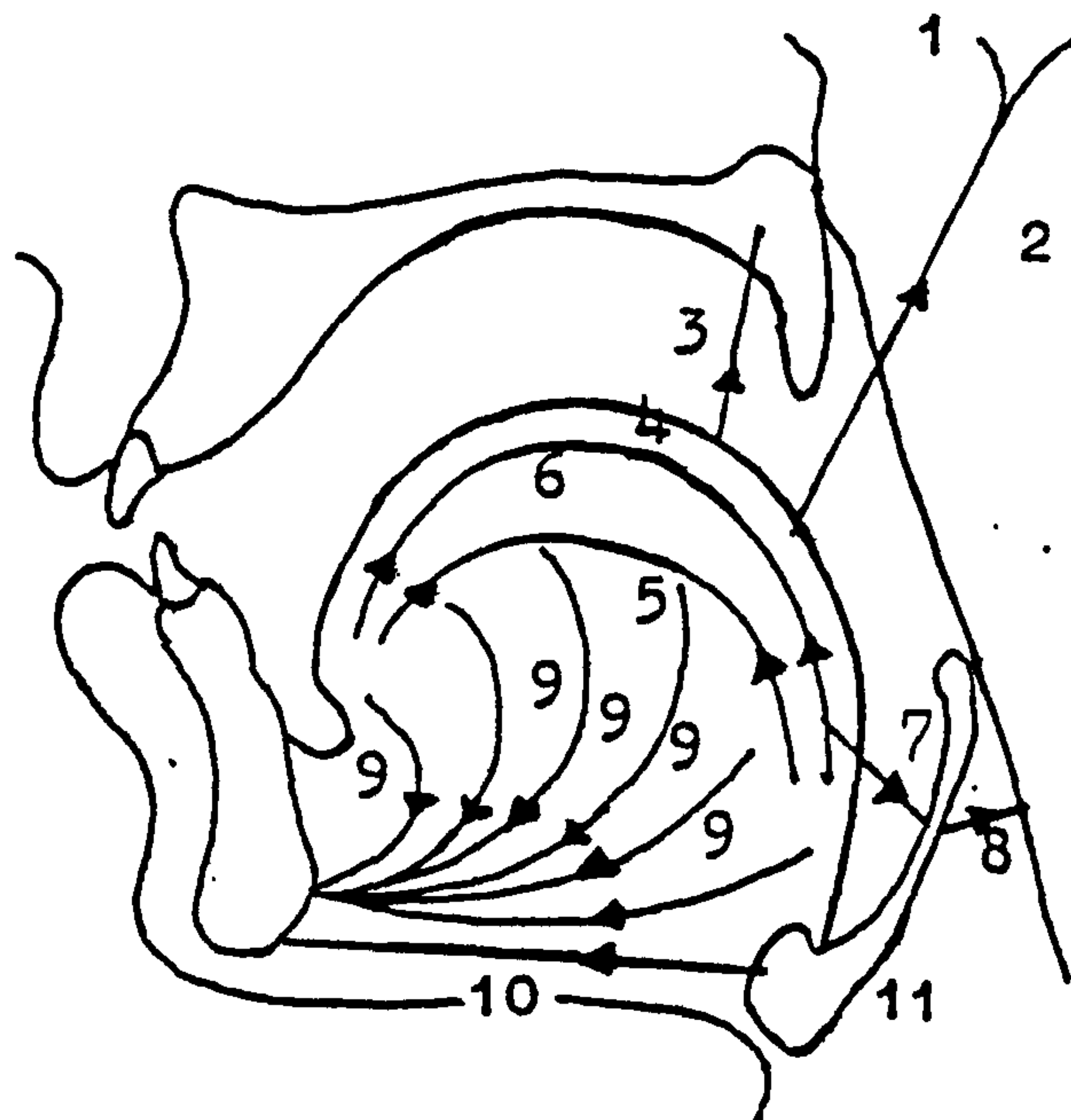
The extrinsic muscles of the tongue attach it to the hyoid bone, the mandible and the skull; their contraction changes its form and its position in the mouth.

The genioglossus is considered to be the strongest of these muscles and its function is to elevate and protrude the body of the tongue. This is accomplished by "antagonistic counteracting tension from the styloglossus, and hyoglossus from a fixed hyoid". (Laver, 1980:54).

The styloglossus originates at the styloid process of the temporal bone and runs downwards and somewhat forwards to insert into the sides of the tongue. The upper fibres extend horizontally to the lip. This muscle lifts the whole tongue upwards. It also draws it backwards.

The palatoglossus has fibres which blend with those of the styloglossus. It lifts the body of the tongue upwards when the velum is fixed.

Figure 2.6 A schematic diagram (from Laver 1980:52) showing the muscles of the tongue and their action in relation to soft palate, hyoid bone and pharynx



1. Styloid process
2. Styloglossus muscle
3. Palatoglossus muscle
4. Superior longitudinal muscle
5. Inferior longitudinal muscle
6. Transverse lingual muscle
7. Hyoglossus
8. Middle pharyngeal constrictor muscle
9. Genioglossus muscle
10. Geniohyoid muscle
11. Hyoid bone

The hyoglossus extends from the hyoid bone to the side of the tongue. It draws the body of the tongue downwards and backwards, an action observed to occur during the articulation of the pharyngeal sounds.

The intrinsic muscles can also change the shape of the tongue and shorten it.

The longitudinal muscles are divided into superior and inferior. They can shorten the tongue.

The transverse "narrows the tongue and thereby protrudes it. It may bulge the organ upward. The lateral margins become lifted to help produce a tongue groove". (Kaplan, 1971:367).

The vertical "flattens and broadens the tongue". (Kaplan, 1971:367).

Sounds which are produced as a result of the restriction of the tongue "are achieved by the contraction of all the muscles of the tongue, together with a contribution from the middle pharyngeal constrictor pulling the body and root of the tongue towards the back wall of the pharynx. The styloglossus, with the palatoglossus acting from a fixed velum and the hyoglossus from a fixed hyoid, equalizing their vertical mutual counteraction, allow their common retracting tendency to help pull the tongue body backwards. The backwards tendency is checked and held to the necessary

degree by the forwards pull of the genioglossus from a fixed jaw position". (Laver, 1980:53:54).

2.6: The Soft Palate

"The soft palate is the mobile and muscular posterior section of the partition between the oral and nasal cavities and between the mouth and pharynx. It is attached anteriorly to the hard palate and laterally to the side walls of the pharynx; it curves downward and backward into the pharynx". (Kaplan, 1971:296).

Muscles of the Soft Palate:

The palatoglossus extends laterally, forward and downward between the soft palate and the sides and the dorsum of the tongue. It lifts the tongue upwards and retracts it. When the body of the tongue is fixed, it constricts the sides of the forward faucal pillars and lowers the velum.

The palatopharyngeus originates in the soft palate and runs laterally downwards and inserts in the posterior border of the thyroid cartilage. The palatopharyngeus muscle forms the back arch of the faucal pillars and in contraction, it narrows the posterior faucal arch, and lowers the velum if the larynx is fixed by the infrahyoids. If the larynx is not fixed, the palatopharyngeus pulls the larynx and lower pharynx upwards.

The salpingopharyngeus elevates the pharynx and constricts it laterally.

The palatal levator originates from the skull at the petrous part of the temporal bone. Its fibres run laterally downwards and forwards to insert into the posterior raphe surface of the soft-palate. It forms most of the muscle mass of the soft-palate and its action widens the fauces by lifting the soft-palate upward and backward. It also elevates and widens the pharyngeal opening of the Eustachian tube. (Kaplan, 1971:302).

The palatal tensor originates at the base of the skull and runs downwards and forwards. It acts with the levator to pull the soft-palate upwards and backwards against the back wall of the pharynx. It tenses the front part of the soft palate.

The uvular muscle forms the body of the uvula and in contraction, it shortens the uvula.

The contraction of the palatopharyngeus and the palatoglossus acting together elevate the larynx and pharynx and constrict the pharynx laterally to produce the pharyngeal sounds /ʁ/ and /ʒ/. Experimental evidence (see Chapter IV), indicates that larynx and pharynx elevation, lateral pharyngeal constriction and soft palate lowering are some of the physiological factors related to the articulation of the pharyngeal sounds.

CHAPTER III

Experimental Techniques

Many new methods of observation have become available to the science of phonetics in the last 20-30 years; some have been developed in phonetic laboratories, for instance, palatography and acoustic spectrography, some have been adapted, for instance, airflow measurement by pneumotachography from respiration and some have resulted from close co-operation, for example fibreoptic laryngoscopes and nasendoscopes, with optical instrument makers.

The techniques used for the data described in this thesis were -

- (a) Fibreoptic endoscopy with video recording
- (b) X-ray recording; static, xeroradiography and videofluorography
- (c) Airflow recording by pneumotachography
- (d) Palatography
- (e) Labiography
- (f) Spectrography

In this chapter, a description of the techniques used is given with an outline of the procedure used in each case. More emphasis is given to the description of fibre-optic endoscopy.

In the case of X-ray, be it static or dynamic, although the technique is immensely valuable in speech research, there are certain limitations attached to it. Because of the inherent danger of exposure to X-rays, subjects are usually reluctant to take part in an experiment involving X-ray radiation. Sophisticated subjects are even more reluctant. The other limitation concerns the total period of exposure. This is always very short which may suffice for medical assessment, but when it is to be used for speech research, the experimenter is faced with the need to record a large amount of data in a very limited amount of time. Static X-ray and xeroradiography generally require a high radiation dosage which severely limits the number of exposures that can be made with each subject. Videofluorography, on the other hand, allows a longer period because of the low-rate of exposure and more examples can be included. Moreover, the dynamic aspect of fluorography provides a means to study the movements of the articulators, as well as sustained positions of certain isolated sounds.

3.1: Fibreoptic endoscopy

A British patent was granted to John Logie Baird (1927) for a method of transmitting light and images by means of flexible bundles of thin glass fibres. It was a considerable time, however, before the idea was taken up and made practical by Hopkins and Kapany (1954), and not until 1968

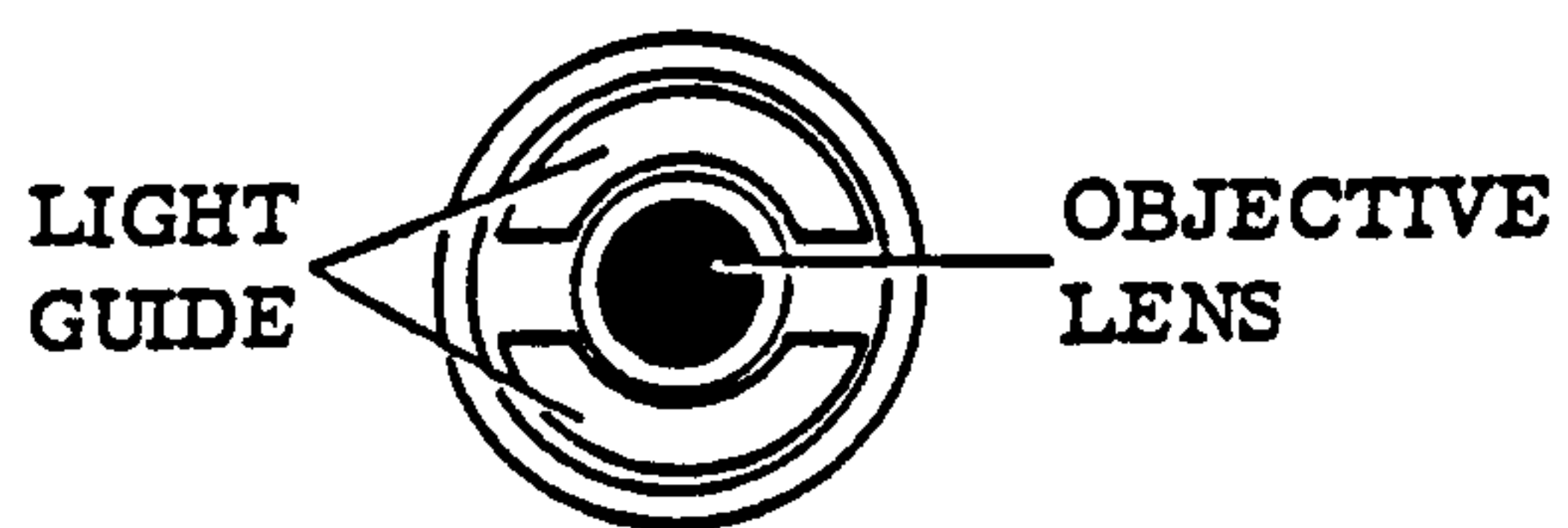
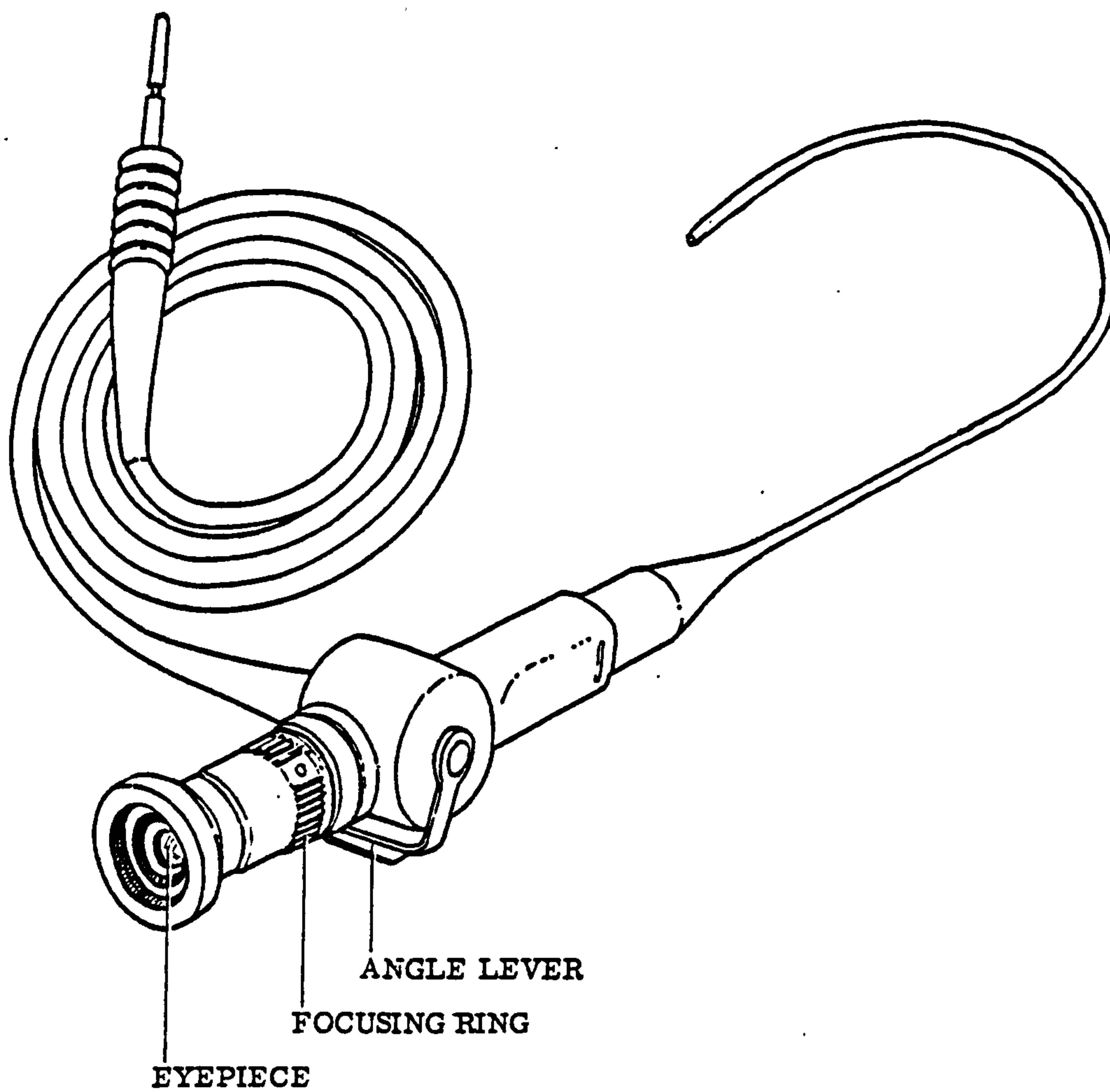
that Hirose described an actual fiberoptic laryngoscope for speech research.

A fiberoptic endoscope consists basically of two bundles of very thin glass fibres. One of these is the light guide required to illuminate what is being viewed at the distal end. The other bundle transmits the image; it is 'coherent', that is, each fibre has the same spatial relationship to its neighbours at each end and so it conveys the image to the eyepiece. A video camera can be connected to the eyepiece of the image guide.

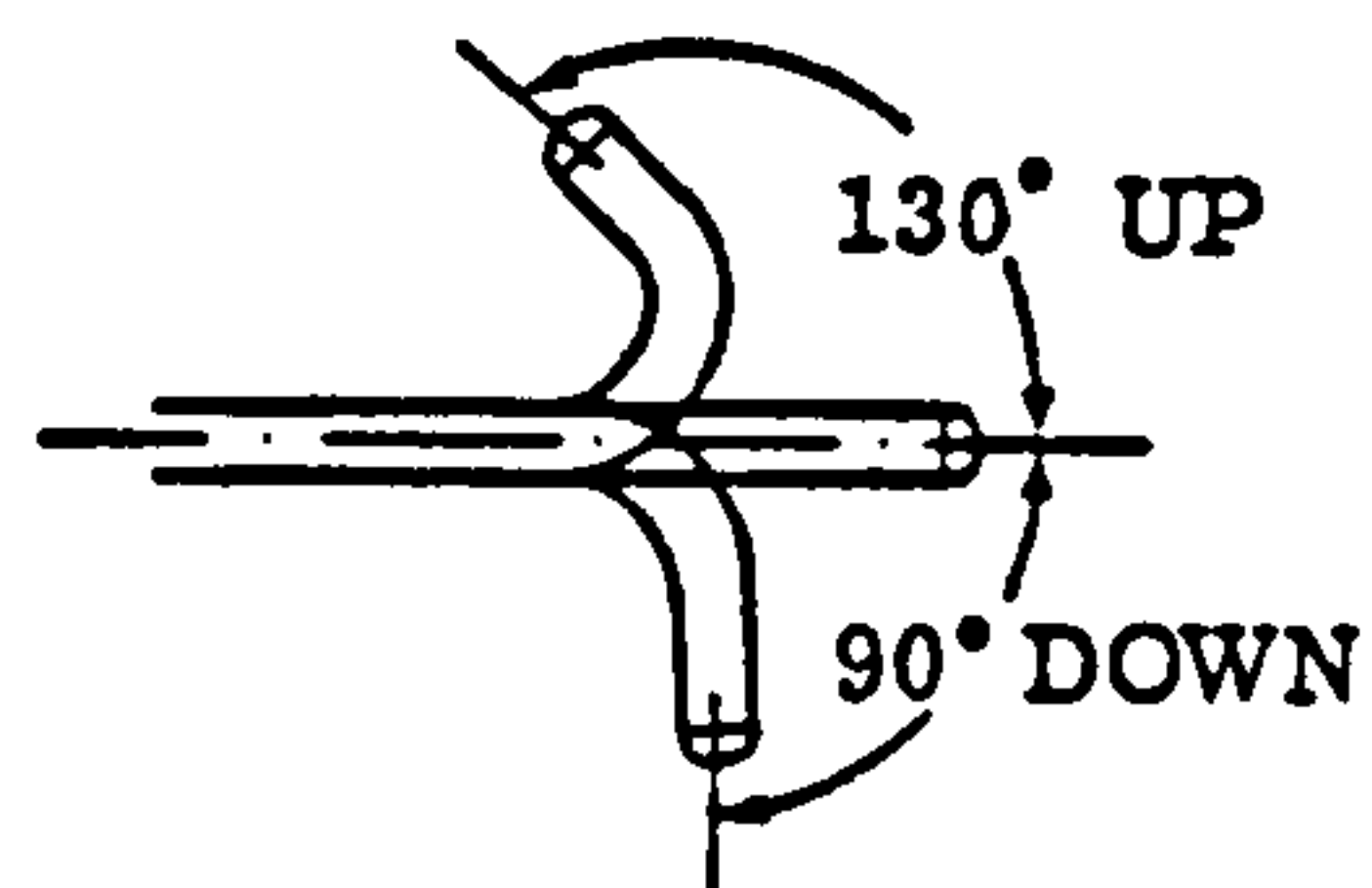
The overall diameter of a fiberoptic endoscope for speech research must be small in order to make it possible to introduce it into the nasopharynx or oropharynx through one of the nasal passages. In the preliminary experiments the diameter of the instrument used was 4.4 mm., but in subsequent experiments, a new version, Olympus ENF Type P with a diameter of only 3.4 mm, was used and an improved remote control system made visualization of the pharynx much easier to obtain. The main problem with all fiberoptic systems designed to date is the serious loss of light in transmission through the light guide, but by using a powerful light source and a sensitive video camera it was possible to record the movements of the epiglottis, tongue and others in colour.

Figure 3.1. shows a drawing of the control section of a fiberoptic endoscope. The long tube connects to the light

CONTROL SECTION



DISTAL END



BENDING SECTION

Figure 3.1.: A schematic diagram of a fiberoptic endoscope

source. The other, short, tube which is flexible also is inserted through the nose. The bending section, has a two-way angulation of 130° up and 90° down, thus giving a wide angle of view. This is controlled by the angle lever on the control section. The distal end, has the light guide and the objective lens for illuminating and transmitting the image of what is being viewed.

As an introduction to the use of fibreoptic, the opportunity arose for the author of this thesis and a post-graduate male student (MB) of the Department of Linguistics, who speaks the Yemeni Arabic of Hadramaut, to be present at the Edinburgh Royal Infirmary while an examination of the larynx of three patients was carried out. The author then was given local anaesthesia in the nose and was seated in a dentist chair. The cable of the fibreoptic bundle was then introduced through the nostril, into the nasal passage and down the nasopharynx. A short list of words was read. The same procedure was carried out on MB. This preliminary approach to the use of the fibreoptic bundle enabled the author to put forward some suggestions for subsequent experiments.

The most important requirements are:

- a) To have the lens in a position just below the velum and above the surface of the tongue in order to see the root of the tongue, the epiglottis, the pharynx and the larynx; when the fibreoptic endoscope is

positioned too low in the pharynx, only the larynx, part of the epiglottis and the back wall of the pharynx, can be seen

- b) To have the words said very slowly, but each part, as far as possible, to be stretched proportionately
- c) To design a list of words and phrases which contain the uvular, pharyngeal and pharyngealized consonants in initial, medial and final positions in the word
- d) It was also thought pertinent to have more examples of /q/ and to examine in particular the action of the lateral walls of the pharynx.

The fiberoptic bundle used for this experiment was rather old and well-used, unfortunately, and there are small black spots on the screen because of broken fibres.

A longer list of 33 words and a short text formed the corpus material for another experiment. The material was designed to include the uvulars, pharyngeals and pharyngealized sounds in initial, medial and final positions in the words.

Two subjects took part, (SA) and (WL). In the Otolaryngology Department of the Edinburgh Royal Infirmary, the nose of each subject was anaesthetised with a pack soaked in a solution of adrenaline and cocaine, which was kept in

position for about 20 minutes. This is necessary to facilitate the insertion of the cable of the fiberoptic bundle in the nose without too much discomfort. The clinician examines both nostrils in turn and chooses the wider nostril. In the usual way of things, size of the nose and the nasal passages do not always match the size of the person.

The experiment proper was carried out in the Cleft-Palate Laboratory in Edinburgh Royal Hospital for Sick Children. The nose pack was removed and the cable of the fiberoptic bundle was introduced through the nostril, into the nose and down the nasopharynx. The distal lens was positioned just below the velum and above the surface of the root of the tongue. This position gave a good view of the upper edge of the epiglottis, the larynx, the back wall of the pharynx, lateral walls of the pharynx and the root of the tongue. It was thought that the distance between the lens and the epiglottis is about 5 cm. long. There were a number of small practical problems, for instance, because the dentists' type of chair used in the Otolaryngology Department of the Royal Infirmary was not available at the Voice Pathology Laboratory of the Royal Hospital for Sick Children, it was, therefore, more difficult to keep the head in the same position which consequently made it difficult to have a steady picture. It was also found difficult to maintain a constant position of the distal end of

the endoscope in the nasopharynx; the bundle tended to twist in speech as a result of the movement of the soft palate musculature.

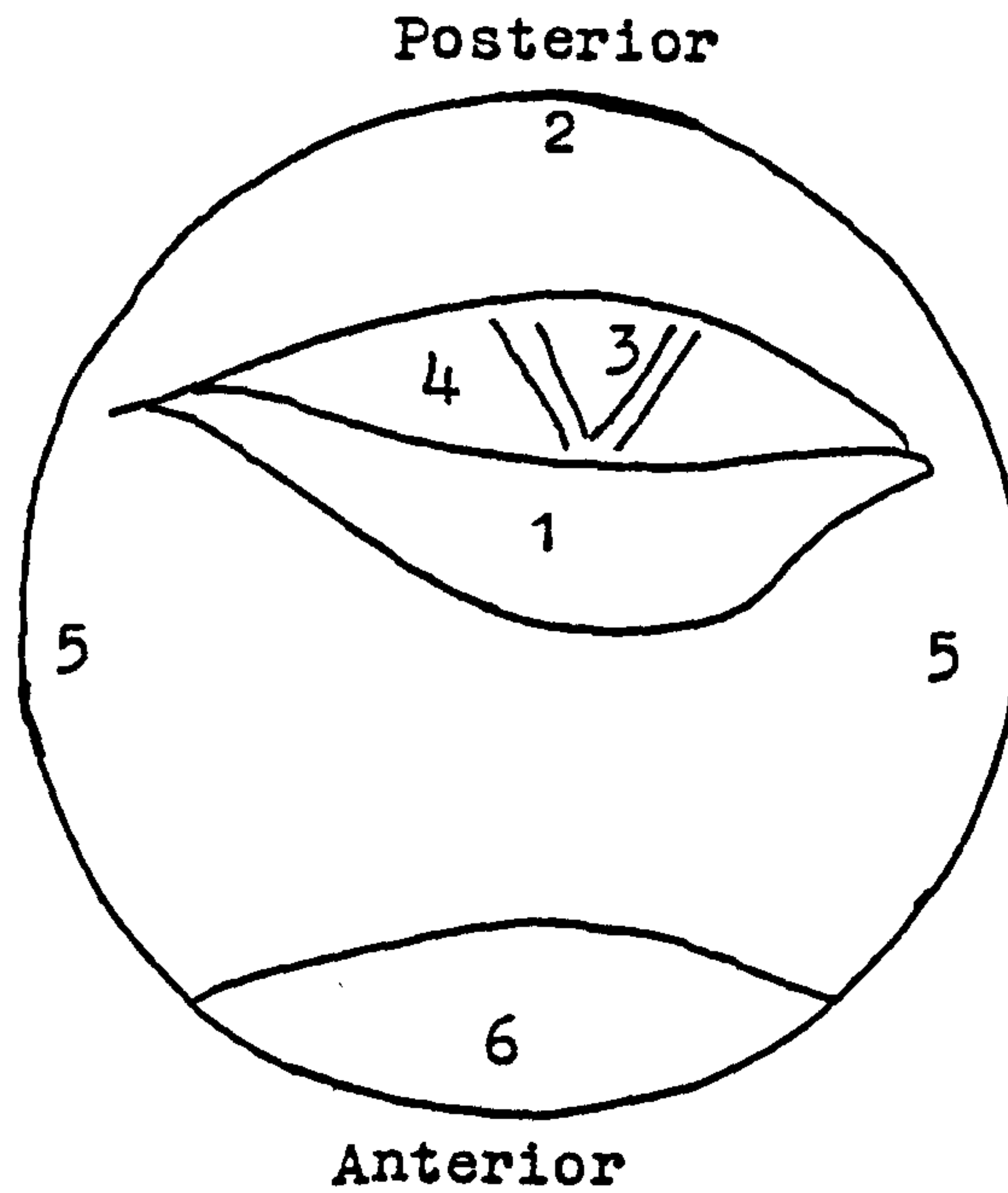
The subjects in turn read the list of words and the view and the sounds were recorded on the Video Tape Recorder. Unfortunately, the recording is in black and white, as no colour video camera was available. It is generally accepted that colour film would carry more information.

The whole video film is about 15 minutes long; it comprised the prepared list of words and text and some conversation between the experimenter and the subject. The video tape was later studied at normal playback speed, slow motion and frame by frame.

On the whole, movements of the epiglottis, back wall of pharynx, lateral walls of the pharynx and the root of the tongue can be seen clearly during the formation of these sounds. A sketch of the pharynx is shown in Figure 3.2.

A subsequent experiment using the fiberoptic endoscope was carried out on subject (FL) in the Speech Therapy Department at the Royal Hospital for Sick Children, Edinburgh. The subject, a physician, sprayed his nose with Lignocaine. After ten minutes, the bundle was inserted through the nostril and the nasal cavity into the pharynx. A colour video camera was connected to the eyepiece of the

Figure 3.2: A sketch of the pharynx as seen through the fiberoptic endoscope



1. Upper edge of epiglottis
2. Posterior pharyngeal wall
3. Larynx
4. Opening between epiglottis and posterior pharyngeal wall
5. Lateral pharyngeal wall
6. Tongue root

bundle. A colour image was then reproduced onto the screen. The video film is about 15 minutes long, and consists of a list of words and phrases read or recited by the subject. Also, conversation between the subject and the experimenter.

Images of the pharynx at different levels and of the larynx were obtained by raising and lowering the bundle as necessary. This enabled the experimenter to have a total view of the pharynx.

The image and sound were recorded on U-matic VTR. The film was later copied on to a colour open reel National VTR N V 3030 E. This enabled the author to carry out the analysis of the film in slow motion and frame by frame on a colour monitor. A black and white monitor (National, model WV - 950 E) was also used.

The image on the screen appears within a circle, its diameter is 55 mm.

Video recording is a valuable technique in speech research, enabling the experimenter to monitor the experiment during recording, thus making any required adjustments, while at the same time obtaining a permanent record of the data from which other copies can easily be obtained. There are some limitations attached to this technique, however. The actual process of monitoring and analysing the video film is excruciatingly slow as the film has to be seen

in normal speed several times, frame by frame, and this proves very difficult to get the required frame instantly; and because of absence of sound at this stage, it is difficult to tell sometimes which sound the articulators are moving towards or away from, especially in the case of fiberoptic endoscopy of the pharynx. In the University of Tokyo, a system was devised whereby a synchronization of a particular frame and a speech signal is easily and accurately achieved, Sawashima (1977). Besides, loss of colour in slow motion or frame by frame is also unfortunate as the image is enhanced by colour. Moreover, the experimenter is always at the mercy of machines and technical problems frequently arise.

The other problem faced with regard to video technique was how to include the relevant examples in the thesis. Photographing the screen was attempted several times. The outcome was not satisfactory, either in the case of fiberoptic endoscopy or videofluorography. The edges of the images were not well defined. Only the very obvious structures appeared, leaving out the other interesting areas that can be seen while looking at the film at normal speed. Failing to obtain good records from photography, tracing the screen was attempted but proved almost impossible. The author then resorted to making sketches of the required frames. The process was very slow, but the results were good and about 230 sketches of the frames showing the articulation of uvulars, pharyngeals and the pharyngealized

sounds and the adjacent vowels were made. The sketches are outlined by a circle to achieve a relative accuracy in relation to the image on the screen. The only problem, with regard to this method, is the inability to get accurate quantitative measurements for these images for obvious reasons.

Sawashima (1977) sums up the limitations attached to the use of fiberoptic endoscopy as:

- a) The effect of the small diameter of the light guide on the frame rate of the motion picture
- b) The effect of the movement of the articulatory musculature on the position of the "scope", which causes variations of the image size and the angle of the "object organ"
- c) Lack of a calibration reference for the absolute dimensions of the "object organ"

Besides these points, the experimenter cannot precisely locate the position of the distal end of the bundle in the pharynx. In Tokyo, a stereo-fiberoptic was used, Fujimura (1977), which gives a stereoscopical view of the pharynx showing the position of the distal end. This is achieved by inserting through the nasal passages two fiberoptic bundles which have independent image fields. These bundles are joined near the eyepiece. They transmit two images side by side on the same frame on the screen. The

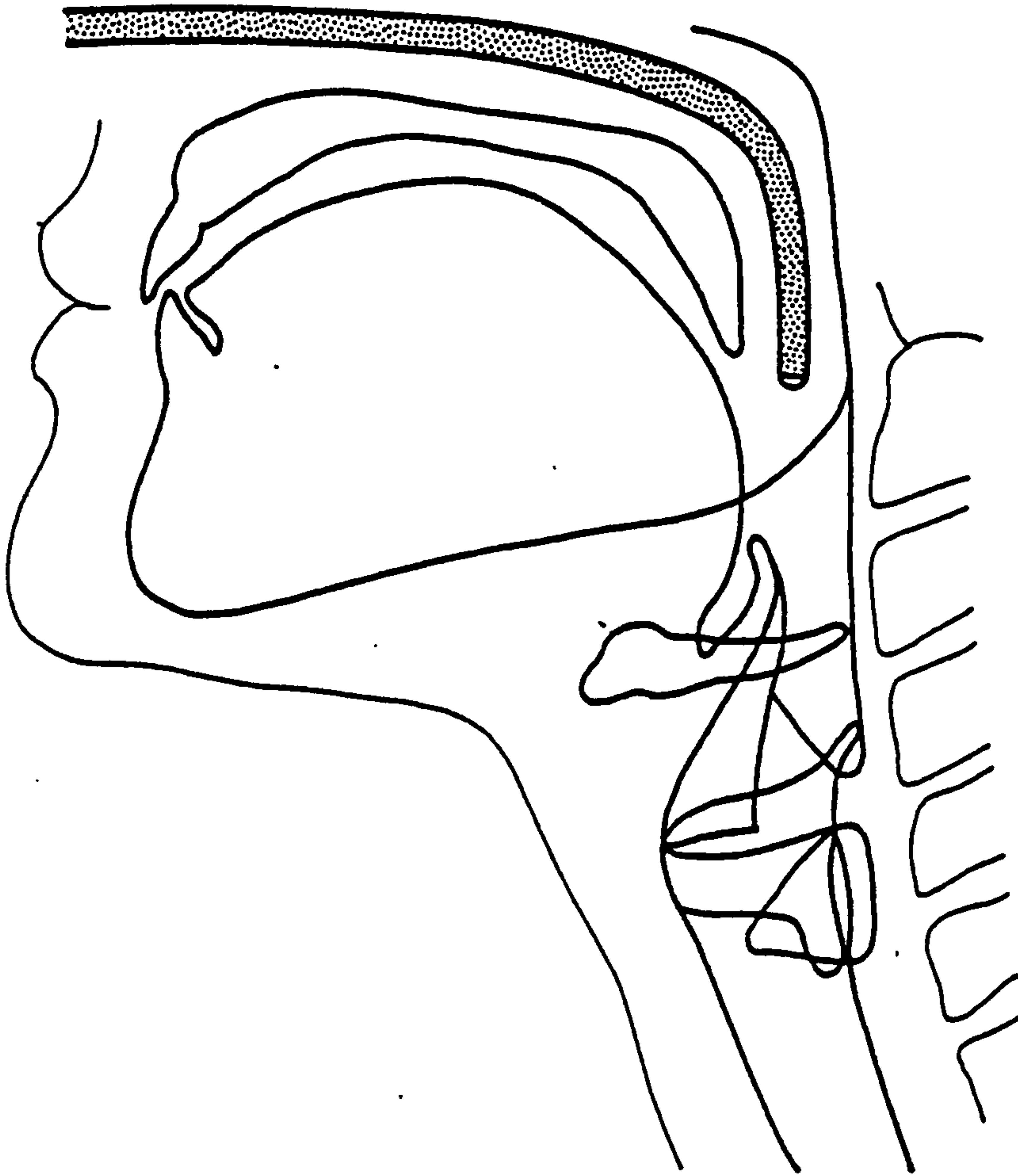


Figure 3.3: Positioning of the fiberoptic endoscope

positions of the lenses at the distal ends are fixed in order to know the distance between the distal end and the "organ". The stereo-fibreoptic endoscope was designed in order to measure "the absolute dimensions of the pertinent structures as well as the vertical movement of the larynx". Fujimura (1977).

Also, a computer controlled radiography technique which X-ray monitors the position of the tip of the fibre-optic bundle was used in the University of Tokyo, Kiritani (1971).

X-rays have a cumulative effect on glass fibres, and so it is not advisable to use the endoscope and fluoroscopy simultaneously. The position then shown here, Figure 3.3. can only be estimated.

3.2: X-ray

A pilot study using the X-ray facilities at Ibn Nafis Hospital, Tripoli, was carried out on an adult male subject, JS. Because of the high dosage rate of radiation, only four exposures were taken, when three words - /ba:3/; /ba:4/; /ba:q/, were being said and one of the position 'at rest', Figure 3.4. Lateral views of the head with pharynx and larynx were obtained.

The experimenter was present with the radiographer to ensure that the exposure was taken at the required instant. It was found necessary to stop each time and see the

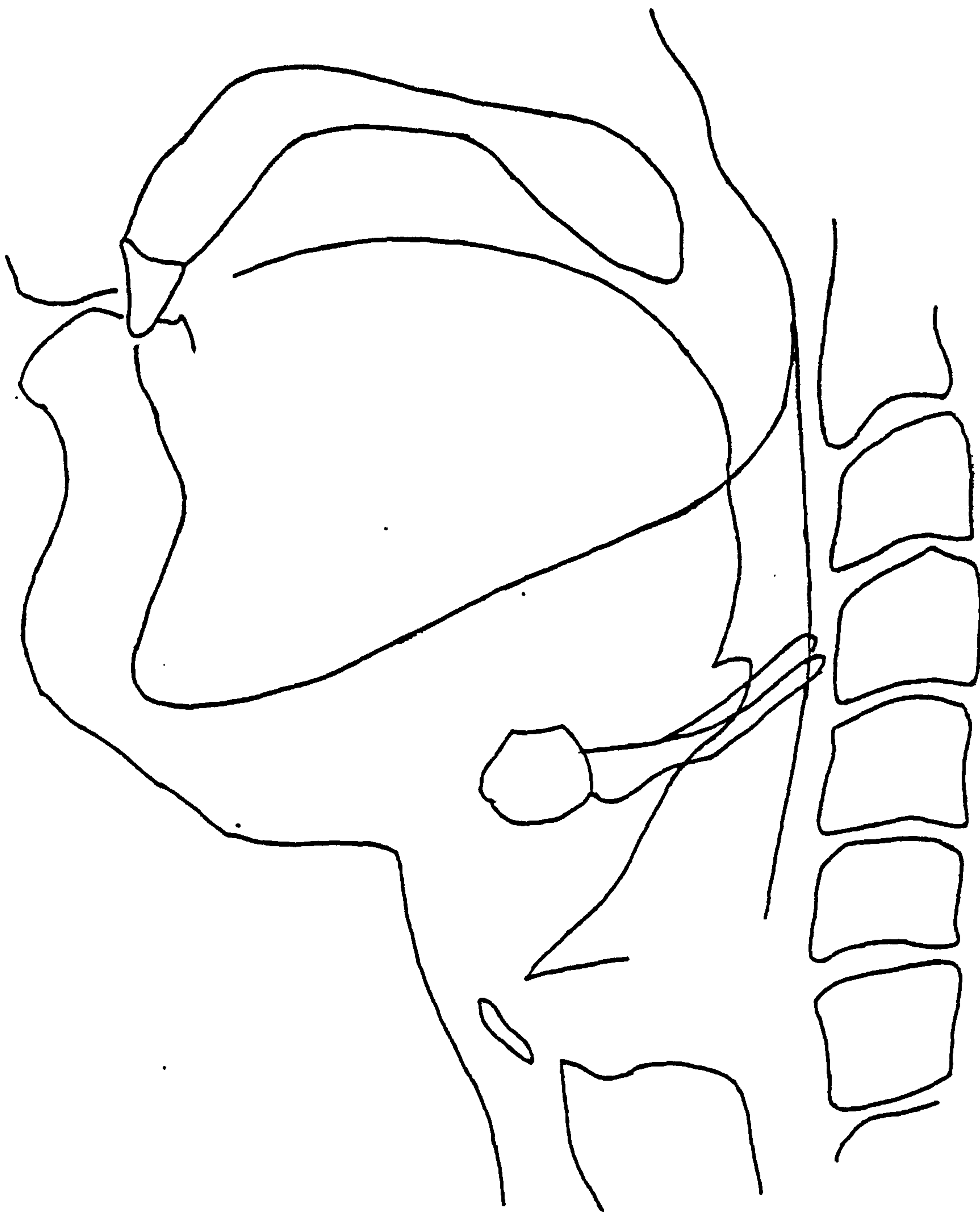


Figure 3.4.:A lateral X-ray tracing of the 'at rest position'. (JS)

processed image.

There was no headrest fitted to this equipment, unfortunately, and so there are differences in head position from exposure to exposure; superposition was, therefore, not as helpful as it might have been. Displacement of the articulators was unavoidable. This, according to Perkell (1969: 8) may be attributed -

"... to slight shifts in the position of the structures, to slight movements of the vertebrae relative to one another, and to a lack of consistency in the X-ray beam and the resulting image".

The X-ray pictures were traced onto tracing paper by using a light box. The edges of the various structures, hyoid, tongue, epiglottis, etc., were not sufficiently well defined, and in some cases experience gained in other X-ray analysis and a reference to published anatomical diagrams by Cunningham (1953) had to be relied on.

3.3: Xeroradiography

"It is a relatively new X-ray imaging technique in which the conventional film is replaced by a charged selenium-coated plate. After exposure, the visible image is produced by electrostatic powder-closed development. The electrostatic development process leads to edge-enhancement of the image (Zeman, Rao, Osterman 1976), which improves visualization of detail in low contrast areas (Bryant and Julian, 1979) and increases exposure latitude,

i.e., enables bone and soft tissue detail to be observed simultaneously. These features, combined with low radiation dose (Noscoe, 1980), make it attractive for viewing the vocal tract, where soft tissues, airway and bone all make important contributions".

MacCurtain(1982)

An experiment using this technique was carried out at Middlesex Hospital, London. The subject, (WL), was seated in a chair with no head-rest, and it was later discovered that the exposures were showing some displacement. Displacement of the structures, due to gesticulation or articulation, is unavoidable, but it appears that this displacement was largely due to the absence of a headrest which keeps the head in a constant position. Attempts to ensure the same position for all exposures has proved to be surprisingly difficult. Any movement of the head may result in taking exposures from different angles each time. Avoiding this is necessary for a quantitative analysis which basically involves tracing the X-ray images and then superimposing each one on the other. Movements due to gesticulation are unavoidable, but to minimise this a headrest is essential; a support of the back or shoulders (against chair) is not adequate.

Xeroradiography has the advantage of showing more tissue, thus the edges are well-defined with regard to, for instance, videofluorography.

The radiation dosage per exposure was 0.3 rem. The subject read seven words and one exposure was made of the 'at rest' position, Figure 3.5. The words were chosen to include the pharyngeals /ɣ/ and /ʕ/, the uvular /q/ and the pharyngealized /L/ and its non-pharyngealized counterpart /l/. The words /ti:m/ and /Ti:n/ had to be included to be used in a project at Middlesex Hospital. The exposures for these two words were taken during the articulation of the vowel /i:/. This is to see if the presence of a pharyngealized sound, /T/, changes the position of the articulation for /i:/. This is done in relation to the non-pharyngealized word. Unfortunately, a simultaneous recording of the sound was not carried out due to noise interference from X-ray machine.

The xeroradiograms are clear and the edges of most structures are well-defined. Attempts were made with regard to tracing and measurement of these xeroradiograms. Tracing of all the xeroradiograms (life-size) was done, and the 'at rest' position was chosen for reference by superimposing each tracing on it.

Alignment was made, using fixed points, for example, the cervical vertebrae. The results were not altogether satisfactory. Ardran and Kemp (1959), cited in MacCurtain (1982), state that fixed anatomical points of reference or straight lines cannot be found, thus quantitative results cannot be obtained. Instead, an approach suggested by

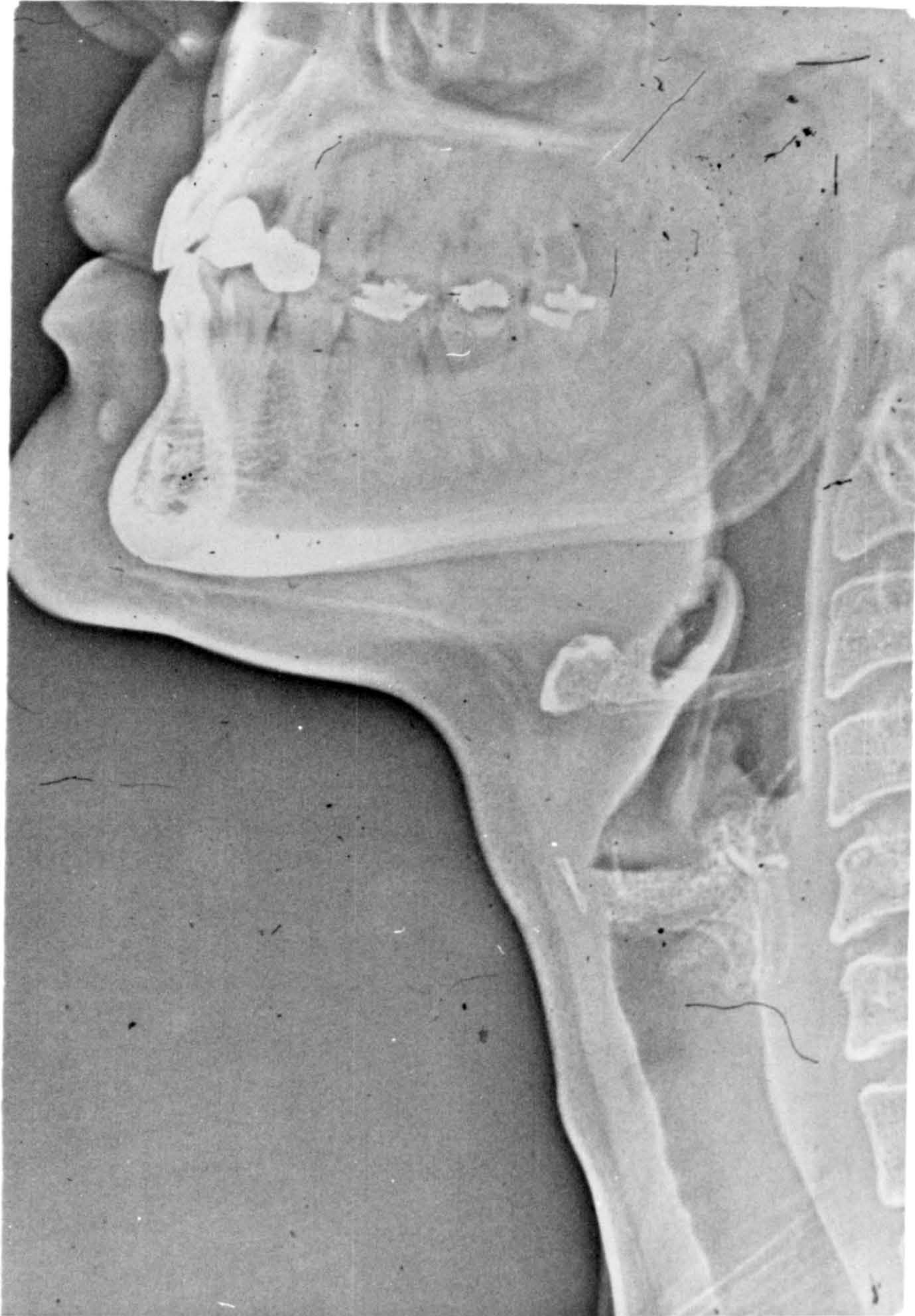


Figure 3.5.: A xeroradiogram of the 'at rest' position

MacCurtain (1982) was applied. Certain points of reference are chosen and the distances between them are measured in all the tracings; comparisons between positions are then made in terms of the changes from those of the 'at rest' position. The following parameters are chosen where emphasis is given to measurement of places of maximum constriction. Figure 3.6 shows these points of reference.

1. Distance between epiglottis and back wall of pharynx at narrowest point.
2. Distance between tip of epiglottis and back wall of pharynx
3. Maximum horizontal dimension of space between root of tongue to front face of epiglottis
4. Distance between tongue root and back wall of pharynx at narrowest point
5. Distance between the top of the body of the hyoid and nearest cervical vertebra
6. Distance between superior surface of tongue dorsum and palate at narrowest point
7. Distance between soft palate and back wall of pharynx at narrowest point
8. Distance between the front edge of C1, C2, C3 and back wall of pharynx
9. Vertical distance from zygomatic arch bone (a) to inferior border of cricoid cartilage (b).

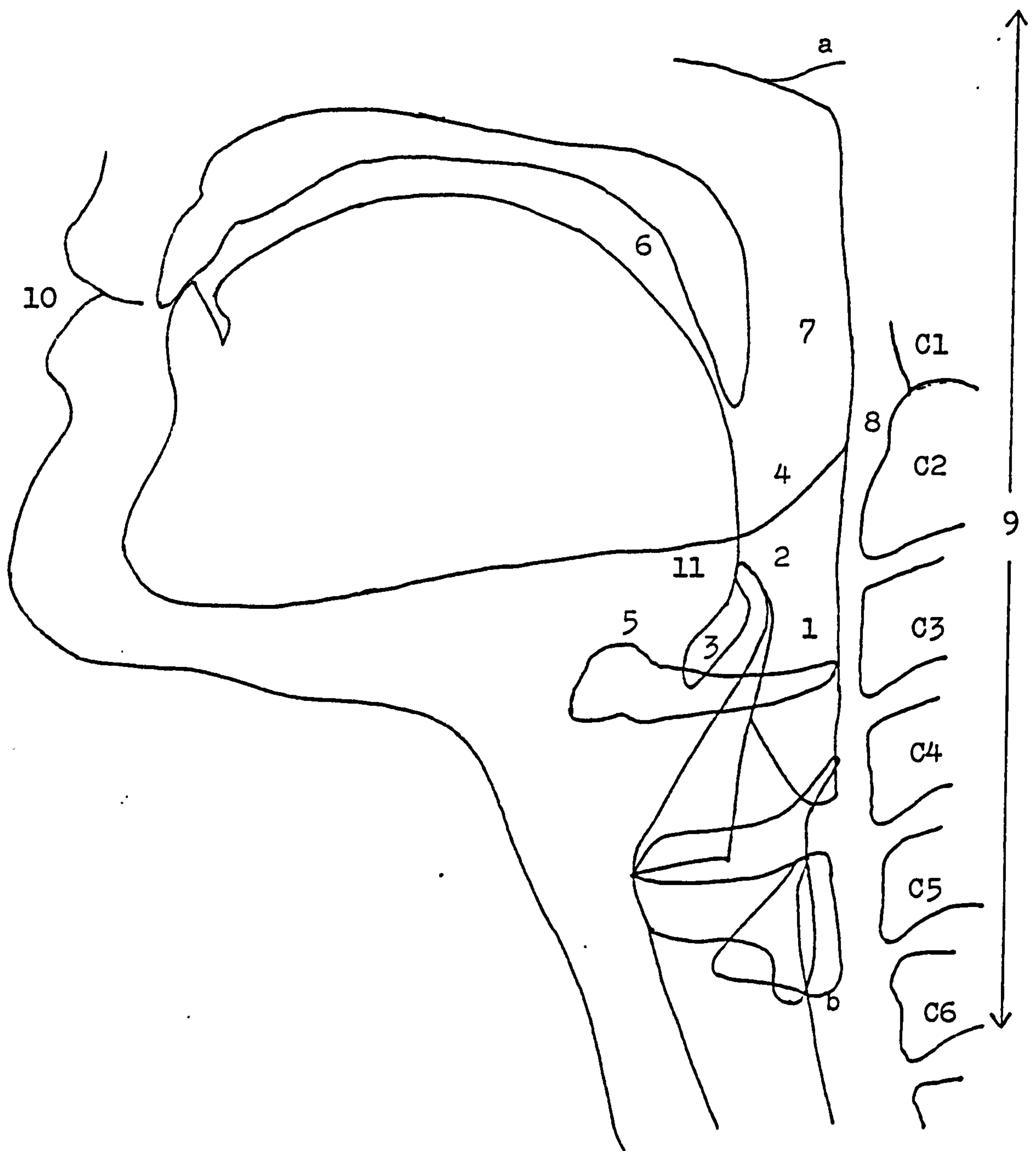


Figure 3.6: Points of reference for measurement of
vocal tract movement

10. Minimum distance between the upper and lower lips

3.4: Videofluorography

Moll (1960: 227) points out the advantages of using cine-fluorography in speech research in relation to X-rays, which have two basic limitations: "a) pictures can be taken only during the production of isolated, sustained speech sounds where the structures are held immobile for the duration of the exposure, and b) the pictures provide only a single sample of articulatory positions during the production of speech sounds". He adds that "... it appears that single-exposure X-ray procedures impose severe limitation on the generalization of results to physiological positions in connected speech". Thus, the choice of using the videofluorographic technique to study pharyngealization in TA to provide according to Moll (1960) "... more than one cross-sectional time sample during speech sound. Thus movements, as well as static, maintained positions, may be studied".

The equipment used was the Siemens Infantscope in the Department of Radiology of the Royal Hospital for Sick Children, Edinburgh.

Operating KV	65 KV
Tube current	1.5 MA
Focus-skin distance	90 cm.
Field size	20 x 15 cm.
Recording	Video
Skin dose equivalent rate	0.68 rem/minute

Under these conditions, the University of Edinburgh Radiation Officer considered that the maximum time of exposure should be limited to 1 minute.

The hospital video-recorder (U-matic) was connected in place of the standard equipment.

Lateral X-ray pictures of the subject (FL), were obtained and the head was kept in position by a device used at the Royal Hospital for Sick Children by J. Anthony. It involves strapping the head with an elastic headband with Velcro tape on the front at the forehead brought against a matching piece of Velcro on a metal arm clamped on a fixed position to the X-ray equipment.

At the start of recording, the subject read the list of words which contained uvulars, the pharyngeals and the pharyngealized sounds. Prior to the start of the experiment, the subject was asked to read the list of words to see how many words he would say within a minute.

The film was copied onto open reel VTR 3030E and a black and white monitor National model WV 950 was used for

the analysis of the videofluorographic film. The film was studied in normal speed, slow motion and frame by frame. For the reasons mentioned above, sketches were made of certain frames which were compared with each other. Importance was given to a) soft palate position for pharyngeal sounds, b) epiglottis movement for all the sounds, particularly the pharyngeals c) the vertical movement of the larynx. An unexpected and annoying finding was that Bluetack, the material used to stick the copper radiation resistance to the back plate, was not transparent to X-ray and shows up as a dark blob. This, unfortunately, appears near the larynx. d) the movement of the other structures, hyoid, tongue, etc.

It was later possible to obtain satisfactory photographs of the required frames of which some are included as examples. The analysis of all the sounds was done in relation to the 'at rest' position.

3.5: Spectrography

The Sound Spectrograph:

A Kay digital Sonagraph (Model 7800) was used for the analysis of the acoustic properties of some of the sounds studied in this thesis. Wide band spectrograms were made of some utterances prerecorded for fiberoptic-endoscopy, videofluorography and labiography of (SA), (FL) and (WL).

Data for acoustic analysis was also obtained from recordings of (JS) under studio conditions.

A spectrograph presents a record of the energy distribution in a sample of speech of approximately 2.5 seconds, with time as the horizontal axis and frequency the vertical. The blackness of the area is proportional to the intensity and so dark bands show the position and movements of the formants, which are the resonant peaks of the cavities of the vocal tract. "A formant being a region of the spectrum where the frequency components are relatively large in amplitude, Painter (1979: 13). "The formants of a sound are thus aspects of it which are directly dependent on the shape of the vocal tract, and are largely responsible for the characteristic quality", Ladefoged (1962: 92).

Frequencies of the formants are dependent on the following factors:

- "a) the position of the point of maximum constriction in the vocal tract (which is controlled by the backward and forward movement of the tongue);
- b) the size or cross-sectional area of the maximum constriction (which is controlled by the movements of the tongue towards and away from the root of the mouth and the back of the throat); c) and the position of the lips".

Ladefoged (1962: 103-104)

3.6: Palatography

Direct palatography was used to study the articulation of some of TA sounds. Ninety-one words were chosen for these sounds, and palatograms were made of them. This technique was developed at Edinburgh University, Anthony (1954, 1968), Abercrombie (1957).

To avoid the use of an artificial palate, the roof of the mouth, that is, the upper teeth, hard and soft palate, was sprayed with finely ground charcoal mixed with a small amount of chocolate powder. Complete and even coverage of this area should normally be achieved, but if not, then the mouth is rinsed and resprayed. The subject, the author of this thesis, then said the word at least three times, the tongue removes the powder in the area it comes in contact with. Once a good wipe-off was achieved, the subject then placed her mouth over mirror A. A reflection of the roof of the mouth is rendered on mirror B, which is positioned in front of mirror A. Both mirrors are adjustable. A camera with a light bulb is fixed on to the frame behind mirror B. A photograph is then taken of the reflection of the mouth. Ladefoged (1957), Painter (1979).

The palatograms were analysed by drawing reference lines across the edges of the teeth, dividing the area into eight zones. Firth (1957), Painter (1979). Dental, in front of the frontal incisor line; denti-alveolar in front

of the lateral incisor line; alveolar in front of the canine line; post-alveolar in front of the first molar line; and pre-palatal, mid-palatal and post-palatal in front of the remaining lines for the remaining molars. Three other lines are drawn between and to the sides of the frontal incisors to the back of the mouth. Three main zones, left, right and central are achieved. The wipe-off is, therefore, measured in relation to these zones. (See chapter 7).

3.7: Labiography

A labiograph of the Phonetics Laboratory at Edinburgh University was used to study the lip position and movements of the sounds that are associated with pharyngealization. The device is described in detail in Azzopardi (1980, 1982). It is basically a metal frame designed to hold the head in a constant precise position which incorporates an adjustable mirror at each side of the face to give (from the front) a lateral view of the lips. The subject, the author of this thesis, was seated on a chair and supported her forehead against the head rest, while the lateral mirrors were in contact with the sides of the face. The vowel phonemes of TA were said in isolation, and in words which contain uvular, pharyngeal and pharyngealized consonants to see the coarticulatory effects of these sounds. The image and sound were recorded on video-tape. (See chapter 6).

The same monitor was used to analyse the film. No photographing of the screen or tracing were carried out. The lip position and movements were observed and studied.

3.8: Airflow

The study of oral and nasal airflow of TA sounds was first done on words containing pharyngeal sounds to see whether there is nasal flow for these sounds (see Chapter 4). Interesting findings with regard to this feature led to the study of airflow of the uvulars and the pharyngealized sounds and comparing the latter groups with their non-pharyngealized counterparts.

The system was that used in the Royal Hospital for Sick Children, Edinburgh, for the assessment of cleft-palate speech, Anthony (1980). It consists of:

- a) an anaesthetic face mask adapted for speech investigation by division into two cavities at the level of the upper lip
- b) a pneumotachographic head, Fleish (1925), fitted in each section for the measurement of airflow through nose and mouth
- c) the Edinburgh Aero Equipment MK II (manufactured by Gaeltic Ltd., Isle of Skye) with electronic amplifiers, transducers, integrators, etc.

- d) a high-speed ink-jet oscillograph with eight channels

The traces on the aerograms show the 50 Hz timing waveform, the laryngographic signal from the vibrating larynx IX, the microphone signal, the waveform of the nasal and oral flow respectively and their filtered versions. Also, the outputs of the integrators for the nasal and oral flow channels. Paper speed is 25 cm/s. For a detailed description of segmentation problems and calibration of oscillograms, see Anthony (1980) and Hewlett and Anthony (1982).

3.9: Pneumotachography with videofluorography

As there were still 10 seconds remaining after the videofluorographic recording had been made of all the technical material, it was decided to attempt to combine this technique with airflow measurement. This was successfully achieved, but the detailed analysis has not been attempted for this thesis.

The words said by the subject, (FL), in this period of 10 seconds, contained the pharyngeal sounds. This was to investigate how nasal and oral flow are determined by articulatory movement in pharyngeals. The procedure is still fairly tentative, and a system will have to be devised to synchronise movements of the articulators and the speech signal with a particular frame, and the position on the airflow record.

3.10: Subjects

The data of this thesis is based on the speech of five Arab subjects; four males and one female in their late twenties and thirties. The two male speakers, (FL) and (JS), were born in Tripoli, Libya, and have spent most of their life there apart from a period during which they went to university, (FL) to Cairo and (JS) to Benghazi, Libya.

The female subject (WL), the author of this thesis, was born in Zelitin, Libya, but since she was two years old she has lived in Tripoli, except for the period she spent in Benghazi and later in England and Scotland to pursue her studies. The three subjects and their families speak the dialect of Tripoli (TA).

The fourth subject, (SA), is an Iraqi from Basra. He went to a 'Koranic' school in the early years of his life, nevertheless, he speaks the dialect of Basra.

The fifth subject, (MB), is a male post-graduate student at the Department of Linguistics. He took part in the initial fiberoptic endoscopic experiment. He comes originally from Yemen, but now lives in Saudi Arabia. He speaks the Yemeni Arabic of Hadramaut.

It was thought plausible to compare specific features of the speech of (SA) and (MB) to the speech of the other subjects. This produced interesting results.

CHAPTER IV

The Pharyngeal Consonants

The pharyngeal consonants, /ħ/ and /ʕ/, have been mainly described in works on Arabic as voiceless and voiced pharyngeal fricatives respectively. Some of their articulatory features have been recognized since medieval times. 'Ibn Sīna', in his 'Risālah' on the points of articulation of speech sounds, described /⁶/ (/ʕ/) as such "... in the production of /⁶/, the obstruction (of the air stream) is again incomplete, but now (the expulsion of the air) is forceful, being driven through the deepest place in the throat, at the opening of the larynx, (where) it is most yielding and most liable to stretch. The expulsion of air is straightforward, so that it agitates and shakes that yielding part equally in all directions; yet without there being any forcing apart or branching". He adds that, "In (the production of /ħ/) the arytenoid cartilage is wide open (while) the nameless cartilage is (only) half way so". (Semaan, 1963). He distinguishes between the voiced pharyngeal and its voiceless counterpart as such "the opening between the two lower cartilages is narrower (than it is in the production of /⁶/, and the air is expelled with a greater forward inclination. (The air) strikes the same border of the concave place which the air of /⁶/ hits while being expelled, and it also strikes that solid edge. The upward

of 35-37

pressure (or the air) is also stronger. (This) forces the yielding membrane, making it advance forwards, and causes therein a forcing apart and an out-branching contrary to what (happens while) / ⁶/ (is being produced), and this is the reason why there is heard there a certain roughness produced by weak acute sound, which mingles (or blends) with the tone". The larynx and pharynx are used here for the three basic functional components of speech production, that is, initiation, articulation and phonation, Catford (1981).

A pharyngeal articulation is basically "one which the root of the tongue assumes the shape of a bulge and is drawn back toward the vertical back wall of the pharynx to form a stricture". (Delattre, 1971:129). Heffner, (1950:152-53), explains that "By drawing the body of the tongue back toward the posterior wall of the pharynx with very considerable force, one can produce a constriction of the pharynx slightly below and behind the extreme edge of the velum".

Heffner's work requires discussion on two points. First, he refers to the fact that the drawing of the tongue towards the back wall of the pharynx involves a considerable amount of force. This confirms the muscular strain that the native speaker of Arabic feels during the production of these sounds, but this muscular strain is not confined to

the tongue but seems to involve all the muscles of the tongue, pharynx and mandible. Secondly, he seems to have based his description on other people's observations, for instance, Gairdner on Egyptian Arabic and Jones on Somali. Heffner's description of Arabic pharyngeals as having a high place of constriction "slightly below and behind the extreme edge of the velum" seems to agree with Catford's view that the Arabic pharyngeal 'approximants' are made by a constriction of the faucal pillars, (Catford, 1977). However, the X-ray pictures of Iraqi (Al-Ani, 1970a), (Delattre cited in Hetzron, 1969), Lebanese (Delattre, 1971), all show a constriction in the oropharynx at the level of the epiglottis against the posterior pharyngeal wall. The author also found from X-ray, xeroradiographic and videofluorographic evidence that the constriction is low down in the pharynx. This is similar to Jones' view (cited in Heffner) of the Somali pharyngeals, where the constriction is made in the oropharynx between the epiglottis and the back wall of the pharynx, with the raising of the glottis and a narrowing of the supraglottal pharyngeal region. Jones' radiograms show this clearly, (Jones, 1931:7).

O'Connor, (1973:42), says that "the very back of the tongue may be pulled backward into the pharynx, thus, modifying the latter's shape and affecting sound quality; this happens in some pronunciations of ah. Pulled farther

back still, the tongue may come so close to the back wall of the pharynx that air passing through causes friction". He cites the two Arabic pharyngeals /ʕ/ and /ħ/. O'Connor put the vowel 'ah' on a par with the pharyngeals as far as the place of constriction is concerned. The displacement of the root of the tongue is made horizontally and not vertically, i.e., the tongue, having the same position in the pharynx as that for the articulation of /a/ or /ɑ/, maintains this position in the pharynx but it moves backwards towards the back wall of the pharynx to form a constriction to produce the pharyngeals.

Chapman, (1973, cited in Laufer and Condax, (1979:60), says that "the tongue root is drawn backward towards the pharyngeal wall to cause a constriction of the pharyngeal cavity". He erroneously claims that the retraction of the root of the tongue "has the effect of flattening the tongue against the bottom of the mouth and pushing the tip forwards", whereas evidence from observation of the tongue during the production of the pharyngeal sounds and from X-ray, xeroradiographic and videofluorographic pictures shows clearly that this is not the case. The body of the tongue assumes a convex shape with the right hand side somewhat lower than the left hand side, though the latter is not significant or consistent.

Catford, (1977:163), distinguishes two main types of pharyngeal constriction, but he has come to realise the possibility of pharyngeal sounds being made at various points in the pharynx. One of these is faucal or transverse in which "the part of the pharynx immediately behind the mouth is laterally compressed, so that the faucal pillars move toward each other. At the same time, the larynx may be somewhat raised". He says that this appears to be the most common articulation of the pharyngeal approximants /ħ / and /ʕ /. This seems to be the same articulation Catford refers to as "simple upper pharyngeal approximants ħ and ʕ "which occur in Avar, a Caucasian language, (Catford, (1981:3), where there is "a rather general, sphincteric, contraction of the oropharynx". He adds that a certain degree of folding of the back wall of the oropharynx can be seen and the faucal pillars move inwards somewhat towards the centre of the mouth. (Catford 'personal communication' explained that this folding can be seen through the open mouth). The author, however, is unable to see this folding in her own articulation. This probably occurs also for Egyptian Arabic, which Catford describes (also personal communication). The other type of pharyngeal articulation for Catford is made when "the root of the tongue carrying with it the epiglottis, moves backwards to narrow the pharynx in a front-back dimension". Contrary to Catford, this type

appears to be the most common articulation for Arabic /ħ/ and /ʕ/, Al-Ani (1970a), Delattre cited in Hetzron (1969), Haskins film (1962), Ghazeli (1977), and the author's evidence from radiographic investigations. The other types that Catford describes are in terms of some Caucasian languages which include "deeper pharyngeal, glotto-pharyngeal or epiglottal articulations", (Catford, 1981:3).

4.1: Views related to the epiglottis

Views vary as to the importance of the epiglottis in speech, i.e., its role as an articulator. Brosnahan and Malmberg (1976:33-34), state that "since it has no direct muscular attachments, the epiglottis can be moved only by movement of the tongue and the hyoid bone. In this way, it can be pushed back and more or less cover the opening of the glottis, thus modifying the timbre of the laryngeal tone". On the same theme, Kaplan, (1971:210), says that "The epiglottis may add to resonance by producing changes in the size of the laryngeal cavity". Heffner, (1950:19), argues that "Although it cannot itself be moved except mechanically, by displacement due to the movement of other organs, the epiglottis may have some influence upon the quality of speech sounds, since it is, in fact, pushed far back over the opening of the glottis for some

sounds, for example, for the vowels of far and ought, while it is pulled forward out of the channel of the breath stream for others, for example, for the vowels of bee or bay".

Zemlin (1968), cited in Laufer and Condax (1979:76), says that "while engaged in high-speed photography of the larynx, the author has witnessed changes in the concavity of the posterior surface of the epiglottis as the subject for photography underwent changes in the pitch of phonation. Thus, it seems as if the aryepiglottic muscle fibres actively engage in modification of the shape of the epiglottis during phonation at various pitches".

Russell, (1931:214), says that "... the position of the epiglottis and its function in deflecting or directing the air current, with its accompanying voice consisting of a concomitant of partials susceptible of alteration by the surfaces and cavities above, must be held to be of vital import. And all those concerned with a study of speech or differences in voice quality would do well, therefore, to observe its varying positions carefully".

Browne and Behnke (1887), cited in Russell, (1931), state that "It is quite plain ... that the lid (of the epiglottis) is the means of more or less suddenly and abruptly turning the tone-waves and of directing them under one angle or another against the back of the throat, whence

they are reflected into the mouth. We are, therefore, justified in concluding that the lid has some considerable influence upon the quality of the voice. It may, thus, be the cause of certain characteristics which enable us to recognise the voice of a friend though we do not see him; and it may also account for some similarities of voice which are found in many families, just as there are similarities of features". Russell (1931), and Cagliari (1978), suggest that movements of the epiglottis may contribute to the introduction of special voice quality to speech.

Gauffin and Sundberg, (1978:162), in their fibre-optic study of cross-sectional shape of pharyngeal constrictions in back vowels, remark that "The point of the maximum constriction in [ɑ] and [a] seems to be located at the upper part of the epiglottis. The very narrow lateral distances for these vowels would efficiently contribute to the constriction. The epiglottis and the surrounding tissues probably constrict the vocal tract more efficiently than the tongue higher up in the pharynx. In these vowels, the lateral width of the constriction seems to depend on the epiglottis".

4.2: The role of the epiglottis in the production of the pharyngeals

The role of the epiglottis in the production of the pharyngeal sounds was first recognised by Max Müller

in Czermak, cited in Willmore, (1905:19). "If the glottis is narrowed and the vocal chords brought near together, not, however, in a straight parallel position, but distinctly notched in the middle, while at the same time the epiglottis is pressed down, then the stream of breath in passing assumes the character of the Arabic $h\ h\ (\dot{h})$, as distinguished from h , the Spiritus Asper, if this hha is made sonant it becomes 'ain. Starting from the configuration as described for hha , all that takes to change it into 'ain is that the rims of the gestures left open for hha are brought close together, so that the stream of air striking against them causes a vibration on the fissura laryngea, and not, as for other sonant letters, in the glottis".

Gairdner, (1925:27), in his description of h , says, "It is probable that in forming it the epiglottis descends leaving only a narrow passage past the vocal chords, through which the air is forced". Jones, (1931) in his description of Somali ς and h using X-ray, found that "the narrowing behind the epiglottis was greater in ς than in h ".

Mitchell, cited in Al-Ani, (1970:158), says "It was, for instance, possible to produce a fricative sui generis from the approximation of the trachea and the under surface of the epiglottal fold (a possibility apparently exploited by the Berber dialect of Zuara in Tripolitania).

Again the "root" of the tongue may be popped in and out of the trachea, the epiglottis may be trilled, the whole speech may be imbued with pharyngeal quality, pharyngeal plosion may be produced and, indeed, occurs in allophones of /q/ in the Arabic of Fez in Morocco".

Mitchell's description is rather vague; it seems that he is unclear in his use of the term 'trachea' and he is, in fact, referring to the approximation of the back wall of the pharynx (trachea) and the base of the epiglottis. As for the trilling of the epiglottis, it was very difficult to see any rapid movement of the epiglottis, probably due to the speed of the film. However, Mitchell's subjective speculation is in agreement with experimental findings of Zemlin, (cited in Laufer and Condax, 1979:76), and Traill's film which clearly shows the trilling of the upper edge of the epiglottis during phonation'. Traill and Anthony (1978).

On this theme, he says (Mitchell, 1975), that "It is a noticeable feature of languages like Arabic and Berber that they make systematic use of consonant articulations that are characterised in important part by the 'fusing' of the epiglottal fold with the rest of the tongue and by the drawing down and back of the whole tongue mass within the pharynx in such a way as to restrict the passage of air between the base of the tongue and the pharynx wall. It is also possible to restrict the air passage

between the top of the trachea and the under surface of the epiglottal fold, leaving a comparatively open pharynx, and it is the writer's belief that this type of articulation occurs in the Berber speech of Zuara in Tripolitania".

In her spectrographic analysis of pharyngeal consonants in Sudanese Arabic, as said in words in a test frame by four male speakers, Adamson (1980), found that the voiced pharyngeal /ʕ/ has allophones which range from an approximant to a stop to a creak depending on the subject, where she found that some used approximant articulation more often than the others, and others tended to use stop or creaky voice articulations. As for /ħ/, the variation between her subjects was not significant and they all produced a fricative sound. She speculatively concludes that "/ħ/ is an epiglottal-pharyngeal fricative and /ʕ/ an epiglottal-pharyngeal stop, with approximant and a creaky voice allophones being the results of uncompleted gestures towards a stop".

Laufer and Condax, (1979), conducted an experiment to prove that the epiglottis has a role in speech, in particular, in the production of Hebrew pharyngeals /ʕ/ and /ħ/, in the production of /a/ and whisper. Their subjects all spoke the Eastern dialect of Hebrew where pharyngeals are still retained, a feature which is dropped in Modern Hebrew. Marbe, (1971:96), states that most Modern Hebrew speakers "though capable of realising these phonemes, do not have them

as part of their sound system of Hebrew, and some speakers without Arabic in their linguistic background realise the voiced fricative as a pharyngeal plosion. Other speakers frequently substitute a glottal stop for the voiced phoneme, especially to mark word-initial stressed vowel onset or intervocalic syllable division". The author found from a study of this film that in most cases Laufer and Condax subjects did not readily produce the pharyngeal sounds /ʕ/ and /ħ/ as they are recognised in Arabic, unless their attention was drawn to them; strangely enough, /g/ was alternatively used instead of /ħ/, and in some cases, instead of /ʕ/. They all have had Arabic in their linguistic background; either they or their parents originally came from Arabic countries. This makes it difficult to explain the absence of this sound in their speech.

Laufer and Condax data comprised words and nonsense syllables and the text of the story of the North Wind and the Sun. The material ranged from slow and careful speech to rapid and casual conversation. A colour video-tape and still films were made using fiberoptic endoscope, which was introduced through the nostril and nasal passage into the pharynx. The tip was positioned slightly below the velum and above the root of the tongue in order to see the posterior wall of the pharynx, the lateral walls of the pharynx, the aryepiglottic folds, the vocal folds, the upper edge of the epiglottis and the root of the tongue.

Their conclusions are supplemented by the dissection of the musculature and cartilages of the epiglottis and larynx in a cadaver.

They concluded that for the pharyngeals /h/ and /ʕ/, the epiglottis moves independently of the tongue root, which is usually out of the range of the picture. They state that "In the extreme position of /ʕ/ that is, in the cases where the epiglottis falls down so that the tip disappears momentarily and then pops back up out of the throat, the epiglottis is clearly making an independent movement, pulled by the contraction of the aryepiglottic muscles, and not merely being pushed back by the tongue". They add that "Properly speaking, perhaps we should call /h, ʕ/ epiglottopharyngeal or even epiglottopharyngeals, but because as far as we are aware the epiglottis is the only articulator found in the pharynx, we will continue to refer to these sounds as pharyngeals". Fibreoptic endoscopic films made for this thesis or those of Laufer and Condax do not show that the tip disappears 'momentarily'

when 'the epiglottis falls down' and 'then pops back up out of the throat'. The action of the epiglottis is mainly to retract with the lid curled forward. It may lower down during its retracting movement. They also state, (1979:77), that "the opening allowing the escape of air is between the epiglottis and the pharynx (never between the tongue and the pharynx, never lateral to the epiglottis)". This correlates with the author's endoscopic and radiographic findings. The author has found that in all cases, the constriction for the pharyngeals is made between the epiglottis and the posterior pharyngeal wall. In other words, the opening is between the epiglottis and the pharynx and not between the tongue root and the pharynx.

Laufer and Condax results show that for pharyngeals, the epiglottis assumes a narrow opening close to the posterior wall of the pharynx and touching the lateral wall of the pharynx. They imply here that there is a great lateral constriction of the walls of the pharynx, which causes the lateral walls to touch the epiglottis or, in other words, the side of the epiglottis. The author found that this great constriction of the lateral walls of the pharynx appears for the Arabic pharyngeals /ħ/, and /ʕ/, where almost a sphincteric constriction occurs very clearly exemplified in the endoscopic photographs of FL. This lateral wall movement apparently takes place at the level

of the epiglottis, but it may take place at different levels in the pharynx, though difficult to determine from the available data except in the case of /q/, which undoubtedly takes place at a superior level in the pharynx and is characterized by its rapid and extensive movement. They show that the epiglottis forms a complete closure for /ʕ/, i.e., "the entire width of the epiglottis touches the entire width of the pharynx" in careful and slow speech. In rapid, casual speech, there is a considerable narrowing of the epiglottis, but can be quite wide producing fully voiced-glides.

They observed from dissections of cadavers, that when the epiglottis reaches the posterior wall of the pharynx, as it does in the production of pharyngeals, it also presses against the apex of the arytenoids, and that when a narrow opening is formed, the epiglottis presses less strongly against the apex of the arytenoids. They found that the aryepiglotticus is continuous with the thyroepiglotticus and thyroarytenoideus, and fibres of all three can contribute to pulling the epiglottis down and positioning the arytenoids under it. They did not see any evidence of the contribution of the glossoepiglotticus or the pharyngoepiglotticus in the detailed dissection.

They observed that in one subject, the arytenoids moved forward meeting the epiglottis as the vocal tract moved to make the constriction.

They found that one of the realizations of /ʕ/ is a voiceless stop which may be produced by a constriction of the epiglottis against the posterior wall of the pharynx, or when the base or underside of the epiglottis touches the apex of the arytenoids. They add that this articulation may be achieved by "a double closure", that is one closure made by the epiglottis against the posterior wall and another by the base of the epiglottis against the apex of the arytenoids. They explain that the air space below the closure is too small to accept air enough to allow voicing to continue for the duration of the closure. They also state that when the epiglottis goes far enough back, it also goes down far enough to touch the arytenoids. This action may "disturb the fine adjustment needed for voicing" and thus a glottal stop or glottalized voice or creak is then produced. They conclude, that /ʕ/ is phonemically voiced, and the vocal folds are always in the shape to produce voicing. A wide constriction results in a glide. A pharyngeal voiced fricative is made when the constriction is smaller. When the constriction is narrower, a creaky voice is produced. For the voiceless pharyngeal fricative /ħ/, they state that the opening is very narrow and it is this which causes the friction. In other cases, the opening is very large, which they reject to be the cause of the friction. In these cases, the friction is caused by the air passing through the constriction made by the

base of the epiglottis and the arytenoids. Or possibly, the constriction is made by the fat pad at the base of the epiglottis just above the level of the top of the arytenoid cartilages.

They reject any importance given to the tongue for the articulation of these sounds. The stricture is not made by the tongue, which only appears in a number of cases a little while after the epiglottis folds down and back. This view is accepted here with some reservation. It appears that even though the tongue root does not appear in the range of the picture for pharyngeals, X-ray pictures show clearly that the tongue root moves far back, assuming a different shape than those seen for the pharyngealized sounds. This is evident in all sagittal X-ray pictures made of Arabic, Al-Ani (1970), Delattre (1971), Haskins Laboratory film (1962).

The Laufer and Condax film shows that in all cases where pharyngeals were produced, the epiglottis always assumed a closer position to the back wall of the pharynx than in the other sounds, except for the open vowel /a/, which had a somewhat similar shape of the pharynx as for the pharyngeals. The degree of approximation of the epiglottis and the pharyngeal wall varied with each subject. Only one female subject, who came originally from Yemen, exhibited a complete closure between the epiglottis and

the back wall of the pharynx and produced a sound similar to that produced by the Yemeni and the Iraqi subjects who took part in the experiments for this thesis, irrespective of the position of /ʒ/ in the utterance. The voiceless pharyngeal /ħ/ had less constriction in the pharynx in relation to /ʒ/, but closer than the other subjects' articulation of /ħ/ showed.

As for the tongue root, it was possible to see part of it in those cases where the pharyngeal sound is followed by /a/ or /o/. Where a close front vowel occurred, the tongue root did not appear in the picture. Even in those cases where a close back vowel /u/ followed the pharyngeal, either the tongue root was not visible, or it only appeared slightly. This is expected because the tongue body assumes a high position in the mouth for /i/ and /u/ and consequently, the tongue root is pulled upwards. A somewhat great inward movement of the lateral walls occurred for this subject.

4.3: Nasalization related to pharyngeals

While studying South-Ethiopic languages, Hetzron, (1969:70-71), observed the occurrence of "non-etymological n's" in certain words, at the end of an initial syllable. This occurrence of n is restricted to the context where there had been an initial "laryngeal" h or ʕ followed by

a vowel, followed in turn, by another consonant. He found that in this context, the "laryngeals" \dot{h} and $\dot{\text{ʕ}}$ become h and ʕ respectively, and a homorganic nasal appears between the vowel and the second consonant. Thus, he concluded that South-Ethiopic languages replaced the "laryngeals" \dot{h} and $\dot{\text{ʕ}}$ by nasalized h , and ʕ and transferred the nasality to the following vowel. This was done to achieve the acoustic impression of the 'alien' Arabic pharyngeals. Hetzron's impressionistic views that Arabic \dot{h} and $\dot{\text{ʕ}}$ have velic opening were confirmed by Delattre's X-ray tracings cited in Hetzron, (1969:70).

Delattre showed that there is a physiological explanation for the fact that vowels are nasalized after $/\dot{\text{ʕ}}/$ and $/h/$, and not after $/\dot{\text{ɣ}}/$ and $/X/$ (Delattre groups the latter two sounds with the pharyngeals). His X-ray film consisted of all the Iraqi Arabic 'laryngeals' in intervocalic position between $/i/$, $/a/$ and $/u/$ vowels. It was found that three articulatory motions occurred for these pharyngeals, regardless of the preceding or following vowel: "(a) the root of the tongue backed very sharply toward the lower part of the pharyngeal wall; (b) the larynx rose considerably (by about 8 mm. after $/i/$, 13 mm. after $/a/$ and 15 mm. after $/u/$; (c) the uvula lowered far down along the root of the tongue and curled up its tip as if to vibrate". (Delattre, cited in Hetzron, 1969:72).

Delattre speculates that when a pharyngeal constriction occurs, the uvula tends to lower its tip to reach the place of the constriction to vibrate. No velic opening occurs for the Arabic /ɣ/ or the French /R/, because the place of constriction is high in the pharynx and the uvula has no difficulty in reaching the tongue without causing a velic opening, whereas the constriction for /h/ and /ʕ/ is very low and the uvula forces the velum to lower causing a velic opening. One tends to see Delattre's view with some reservation, though not to reject it completely. Velic opening is shown in Delattre's X-ray tracings (Hetzron, 1969) of the Iraqi voiced pharyngeal /ʕ/. It is also found in the xeroradiographic and video-fluorographic pictures included in this thesis (see 4.5). Also, MacCurtain's xeroradiogram of the Iraqi /ʕ/ (1982), shows it although no reference to this feature is made. However, as for Delattre's explanation behind the lowering of the velum, that whenever there is a pharyngeal constriction, the velum leaves its initial position to move to a point just above the constriction which is favourable for vibrating, two points have to be considered.

First, it is possible that an indirect relationship of some kind exists between the constriction and the velum's movement. This takes place also for the articulation of the open vowel /a/, though to a lesser degree. Secondly, Delattre implies that the friction of the pharyngeals is

effected by the tip of the velum against the place of constriction, though very speculatively. This may well apply to /ɣ/, but it is difficult to accept when it comes to /ʕ/. However, one cannot reject the role of the tip of the velum in modulating and giving the pharyngeal /ʕ/ its unique timbre; other complex factors almost certainly come into play in the production of the pharyngeals.

Airflow measurements of Ghazeli (1977), did not show any "nasal leak" for the pharyngeals. He found that the average flow rate through the nose for /ʕ/ and /ħ/, (/ħ/ = ẖ) was almost the same as that for /s/ where a complete closure is usually effected. He found that for the nasals /m/ and /n/, there was a variation in the flow rate between 8 to 15 litres/minute. He also found that the values of the flow rate for vowels adjacent to nasals varied from 5 to 12 litres/minute. This finding was confirmed by his cinefluorographic film and he concluded that even though the soft palate makes contact with the pharyngeal wall along only a small area, a "complete velic closure is maintained".

Marbé (1971), states that pharyngeals in Modern Hebrew are usually articulated with velic closure, though alternatively, some nasalization may occur. Here he does not really attribute nasalization to velic opening. It is implied that nasalization can still occur even if a velic closure is maintained.

While Ghazeli's cinefluorographic tracings of /ʕ/ and /ħ/ in Tunisian Arabic do not show a lowering of the soft palate, Delattre's X-ray tracings of the Iraqi subject clearly show this for /ʕ/, as no evidence is given for /ħ/. However, he claims that this feature is present for the voiceless pharyngeal /ħ/ as well. (Delattre, cited in Hetzron, 1969). However, his tracings of /ħ/ and /ʕ/ of a Lebanese subject, Delattre (1971), fail to show a lowering of the soft palate; contact seems to take place between the soft palate and the nasopharynx, however.

Both lateral xeroradiograms of /ʕ/ of the Iraqi subject, (MacCurtain, 1982), show a small opening between the soft palate and the back wall of the pharynx, an indication that airflow can pass through the nose as well as through the mouth.

Whether the feature of velic opening related to pharyngeals exists in some Arabic dialects and not in others is difficult to tell as yet. One is inclined to say that idiosyncratic factors may be involved.

Willmore, (1905:18), in his description of the pharyngeals, says that "A portion of the breath is forced with some violence through the nostrils".

Other factors may contribute to nasalization.

Ghazeli speculates that the peculiar vibratory pattern of the vocal cords associated with /ɣ/ may be the cause of the auditorily perceived nasalization for /ɣ/.

He agrees with Curry (1910), who "postulated that nasality could be caused by insufficient velopharyngeal closure, by pharyngeal constriction, by excessive tensing or by a combination of all of these". (Cited in Zemlin, 1968:210 and Ghazeli, 1977:42).

Cagliari, (1978:107), states that "the movements of the epiglottis can change the configuration of the vocal tract in such a way that a side chamber is formed between the tongue and the epiglottis in the lower pharynx, with the consequent introduction of a special voice quality to speech". Russell, (1931:42), suggested that nasality can be produced by this special positioning of the epiglottis, especially the nasality that characterises the so-called nasal twangs.

Cagliari and Russell here attribute nasality to other factors involving the epiglottis and not the soft palate. It is understood here that a velic closure is present in which case the positioning of the epiglottis in a position that creates a chamber with the tongue is the cause of nasality. This chamber can be seen in X-ray tracings of the pharyngeals.

4.4: The controversy related to /ʕ/

The pharyngeal consonant /ʕ/ has been, and still is, a focus of controversy among linguists and phoneticians. /ʕ/ in Arabic is generally described as a voiced pharyngeal fricative. It is, however, found to have allophones which range from fricative, approximant and a stop. Though views are more or less in agreement with regard to the first two allophones, it is the latter that is found to be the centre of controversy with strong views supporting it and others equally strongly refuting it. More experimental study seems essential to reach a conclusion. Here, though /ʕ/ in TA ranges from fricative to approximant, it is thought pertinent to compare TA to that of Iraq and Yemen to attempt to see the similarities and the differences that exist between this sound in these dialects.

Experimental studies, using fiberoptic endoscopy, (Laufer and Condax, 1979, 1981 and the experiments carried out for this thesis) have been useful in shedding light on the function of the pharynx in speech, which is inaccessible to normal observation. Studies of the interaction of the complex muscles of the pharynx (see Chapter 2) are also necessary. Xeroradiography, which shows more tissue than other types of X-ray is, unfortunately a static procedure; moreover, it is difficult to see all the muscles.

Heffner, (1950:152), argues that nostop consonant is produced by a constriction in the pharynx, "but distinctive pharyngeal fricatives are produced". Ladefoged, (1971:41), says "In the pharyngeal area, however, no languages use stops (most people cannot make them) ... Even fricatives are not very common". Catford, (1970:326), doubts the occurrence of a stop in the pharyngeal area by stating that "At the epiglottopharyngeal location it is doubtful if a stop articulation can be formed, since it seems to be impossible to make a perfectly hermetic closure between epiglottis and pharynx wall - stop-like sounds produced in this way appear to involve glottal closure as well as epiglottopharyngeal close approximation. However, epiglottopharyngeal fricative, approximant and possibly trill can be produced. At the pharyngeal location, fricative and approximant strictures are possible". Catford later (1981), accepted the fact that a "glottal stop" type phoneme occurred in Chechen and other Caucasian languages which has been described as a pharyngeal stop or as a "glottal + ventricular stop + pharyngeal constriction". He took Laufer and Condamine's view that a pharyngeal stop can be produced by an "epiglottal arytenoidal constriction or closure", (Catford, 1981:3). His use of the term "approximant" is justified on the grounds that /ʕ/ has "non-turbulent, non-fricative airflow". This may be the reason behind the tendency of some Arab grammarians not to include the voiced pharyngeal /ʕ/ among the

fricative consonants which puts it on par with /m, n, l/ Anis (1961), Ridwan (1976). Shaheen (1979), in his acoustic study of Egyptian Arabic consonants groups /ʕ/ with the semi vowels /w/ and /j/, and not with the fricatives as is commonly the case. He found that "the spectra of /ʕ/ in initial, intervocalic, and final position show no trace of the random scattering of noise characteristic of fricative consonants. By contrast, these spectra are characterised by a clear formant structure very much like that of the Arabic vowels". He refers to the difference in the spectra of /ʕ/ and the Arabic vowels where for /ʕ/ he found, in agreement with Al-Ani (1970), that the /ʕ/ is characterised by wide spacing between voice striations. He, however, suggests that because this feature characterises creaky voice as well, the source of voice is identical in both cases.

Odisho, (1973:72), stresses the existence of certain degrees of pharyngealization and laryngealization for /ʕ/*. He explains the relation of these two features, "i.e., when the former increases, the latter becomes greater. And if the latter becomes greater it will put the vocal cords in such a state that they can hardly vibrate; moreover, the aperture of the glottis will allow only a small amount of air flow that is incapable of producing friction noise at the pharyngeal stricture. The reverse of this state will give us a fricative/approximant sound because

less pharyngealization may lead to less laryngealization, both of which will allow greater airflow that is capable of setting the vocal folds to vibrate properly and even cause slight friction". Odisho concludes that the voiced pharyngeal /ɣ/ "swings between being an approximant and a laryngealized approximant, depending on the context in which it occurs and the vowel quality accompanying".

The feature of pharyngeal plosion is referred to by Mitchell, cited in Al-Ani, (1970b:158), where he says that "... pharyngeal plosion may be produced and indeed occurs in allophones of /q/ in the Arabic of Fez in Morocco". He accepts Al-Ani's view of having an allophone of /ɣ/, which is voiceless pharyngeal stop. Also remarks that he believed impressionistically that "/ɣ/" in Kuwaiti Arabic in most environments involves concomitant features of glottal closure and pharyngeal constriction, and to differ from /ɣ/ in for instance Egyptian and North African Arabic".

Al-Ani was the first to draw the attention to this controversial feature regarding the stop allophone of the voiced pharyngeal /ɣ/. In his instrumental study of Iraqi Arabic, (1970:62), he found that the most common allophone for /ɣ/ is a voiceless stop and not a voiced fricative. He supported his analysis of Iraqi Arabic with reference to Saudi, Kuwaiti and Jordanian Arabic. Al-Ani says

"In all previous works on Arabic, classical, modern and various dialects - the /ʕ/ has been described as a voiced pharyngeal fricative and has been classified as the counterpart of /ħ/. However, after a careful acoustical examination of the /ʕ/, it was surprisingly noticeable that the most common allophone of the /ʕ/ is actually a voiceless stop and not a voiced fricative". Al-Ani points out that there is a phonemic contrast in Iraqi Arabic for /ʕ/ v /ʔ/. Though his spectrograms show a blank space which can be interpreted as being a closure for a stop, he has not been able yet to establish where this closure takes place. He speculates along with Abramson (in the discussion) that the closure is being maintained as a glottal stop along with the 'hamza' /ʔ/. He further ventures in speculating that the closure could be made by the false vocal cords. However, he stresses the existence of a pharyngeal constriction by the narrowing of the root of the tongue against the back wall of the pharynx which produces the pharyngealization of /ʕ/ and the conditioned vowels. His X-ray films, however, show slight narrowing of the tongue root against the back wall of the pharynx, but there is no closure.

Al-Ani interprets his spectrograms of the initial /ʕ/ as a burst followed by a random noise where the burst appears first as a vertical line followed by noise, which varies from one example to another. When it occurs as a

second member of a medial cluster and the preceding consonant is other than a stop, then /ɛ/ is either a glide or a stop in careful speech. For Al-Ani then, /ɛ/ can be realised as a fricative, a glide and a stop mostly in slow careful speech.

Marbé (1971), states that in modern Hebrew "allophones of /ʕ/ range from the pharyngeal plosive to the pharyngeal semi-vowel, through all the stages intermediate between these two extremes". He describes Hebrew /ʕ/ and /ħ/ as fortis/lenis (voiceless/voiced) pharyngeal stops, usually with velic closure though there may alternately be some nasalization, and with the airstream obstructed by the root of the tongue in the mid-pharyngeal region.

Marcais, (1956:24), describes the voiced pharyngeal /ʕ/ as a result of "constriction momentanée" and that "Elle paraît s'effectuer par un mouvement brusque, presque brutal, dont l'amplitude, chez certains, donne l'impression d'une occlusion". He investigated this instrumentally.

Ghazeli (1977), found that the voiced pharyngeal /ʕ/ of his Iraqi subject is not a stop and had formant patterns identical to those of the other dialects investigated, Tunisian, Libyan, Jordanian, Egyptian and Algerian. His spectrographic analysis of /ʕ/ show that the formant frequencies are similar to vowels except that the "vertical

spikes indicating glottal pulses" are wider in /ɔ/ than in vowel formants, an indication that the vocal cords vibrate at a lower frequency.

Based on a spectrographic evidence of /ɛ/ in Iraqi Arabic, Odisho argues and rejects Al-Ani's view that the most common allophone of /ɛ/ is a voiceless stop. Both Al-Ani and Odisho speak the Iraqi Arabic of Baghdad. Odisho attributes the discrepancy in the description of /ɛ/ between himself and Al-Ani partly to the idiosyncratic differences of their articulation of this sound, and partly to their interpretation of the acoustic data. Though factors of idiosyncrasy cannot be ignored, from personal observation of the speech of Iraqi Arabs from various parts of Iraq such as Musul, Baghdad, Basra and other areas, one can say that the similarities are great whether the pharyngeal /ʕ/ occurs in an initial, medial or final position in a syllable or word or when it is geminated, and in rapid or slow speech. Experimentally, it was possible to study this in the speech of an Iraqi from Basra (SA). It is not the aim of this thesis to carry out a cross dialectal study of the pharyngeal sounds, as it is beyond the scope of this work. A study of this type would, one would think, produce many interesting and important findings, but it may not be feasible because of the problems involved, such as the great number of dialects even in one country.

Although the similarities appear to be relatively great in the production of /ʒ/ among Iraqi speakers of different areas, one cannot be so confident when the description involves the study of the dialects of Libya. Even if one divides the dialect areas into three groups, western, eastern and southern, taking the western part, differences still exist between the pronunciation of the Tripoli Arabic and that of the other areas of the west.

The other side of the discrepancy concerns the interpretation of the acoustic data. Odisho agrees with Obrecht (1972), in his review of Al-Ani's (1970), who says that in '/ʒa/' "the rapid excursion, at the beginning of the vowel, is that the excursion is the /ɛ/ in progress, which would make it a voiced continuant rather than a stop". Obrecht, however, agrees that some of Al-Ani's spectrographic data clearly shows a stop. Odisho, on the other hand, states that "... a quasi-blank column on a spectrogram does not necessarily indicate that the sound is a stop, particularly when there is no clear evidence of a spike representing the release of the occlusion". Al-Ani's spectrograms of the words /waʒʒada/, /saʒʒala/ and /saʒala/ and /samaaʒ/, (1970:68-71), evidently show a blank and not a 'quasi-blank' as Odisho says. The spectrogram of the word /saʒʒala/, for instance, does not differ from that of the word /saʔʔala/ as far as the

blank spaces for the segments /ɛɛ/ and /ʔʔ/ are concerned. Spectrograms made from endoscopic recordings of the words /ʒadd/, /waʒʒada/ and /sama:ʒ/ of SA, displayed no acoustic energy during the segment /ʒ/. This was followed by a sharp onset of the following segment, which indicates the release of a stop.

In other cases, the larynx seems to vibrate at a low frequency shown in the wide striations during the segment /ʒ/ in /raʒa/. A study of the acoustics of speech would show a stop, which is described as a posture, that is, "a positioning of the articulators producing a stricture of complete closure", (Abercrombie, 1967:140), as a blank space on the spectrogram.

Odisho attributes the absence of "clear-cut traces of bursts" on the spectrograms to the absence of tight glottal closure "the glottis is highly constricted; only a small amount of airflow is allowed which is insufficient to cause such active excitation of the glottis as would be clearly displayed on the spectrograms". He adds that "Because of the low rate of airflow, pressure behind the pharyngeal stricture is judged to be so low that it can generate only feeble friction and turbulence, if any. The frequency of vibration of the vocal folds is so low and the friction at the pharyngeal stricture is so feeble that they leave hardly any traces on some parts of the spectrograms". In the light of this assumption, Odisho

interprets Al-Ani's traces of /ɛ:/ as "... a mixture of slight 'voice' and noise displayed as anticipating the lower formants of the subsequent vowel elements". He thus prefers to describe /ɛ/ "as a highly laryngealized fricative". Odisho stresses the presence of laryngealization though in various degrees. If the laryngealization is slight, then /ɛ/ will appear as a vowel-like segment, if it is great, it will appear as a quasi-blank segment. (Odisho, 1973:77-78).

Shaheen (1979), also rejects the interpretation of the acoustic data of Al-Ani's /ɛ/ as a pharyngeal stop. He draws a comparison between the spectra of a creaky voice and those of /ɣ/, where the voice striations are wider at the initiation and termination of creaky voice with a concentration of the acoustic energy in the lower frequencies. These wide striations resemble what Al-Ani refers to as the spikes denoting the plosion phase of a stop. Shaheen regards these 'spikes' of Al-Ani's /ɛ/ in word-initial and final position as the wide striations that characterise the initiation and termination of creaky voice. Shaheen attributes this feature of wide voice striations present in the spectra of creaky voice and /ɣ/ to "a restricted form of glottal vibration presumably taking place at the anterior vocal folds only". Shaheen, however, did not refer to the spectrograms of Al-Ani's words of /ɛ/ in medial position.

Adamson, (1980:89), found that the voiced pharyngeal /ʕ/ has stop allophones which "... are characterised by sharp F1 and F2 movements towards each other, followed by a brief period of creaky voice, with the formants continuing their movement until complete closure is effected". She supports her conclusions by two spectrograms of the words /ʃaʕ/ and /ʕiz/. She adds that "Release generally consists of one or more creaks, together with some low frequency voiceless friction. No voice bar is present, since the volume between the larynx and the place of closure is not sufficient to allow voicing". She finds it difficult to distinguish between the transitions of /ʕ/ as creaky voice and that as a stop, especially in a word-final position. She concludes that "the stop articulation seems to be the ultimate target of /ʕ/, but the gestures do not need to be completed to allow the phoneme to be perceived as /ʕ/".

MacCurtain (1982), in her xeroradiographic study of pharyngeal voice quality, found that Iraqi /ʕ/ is characterised by a complete closure made by the tip of the epiglottis and the back wall of the pharynx at the level of C3 without a direct contact of the root of the tongue. She also found that the mode of vibration of the vocal and arytenoid folds IX is similar to that produced in Arabic stops, which suggest that the main muscle groups involved in the production of /ʕ/ are supraglottal. And she

described /ʕ/ as a pharyngeal stop. MacCurtain's xeroradiograms show a complete closure in the pharynx, not only between the tip of the epiglottis, but with almost the whole of the epiglottis and the back wall of the pharynx. Other xeroradiograms of the same subject of the 'emphatic' consonant of /t̤i:n/ show a very close constriction in the upper oropharynx. One is inclined to interpret this great constriction either for the pharyngeal /ʕ/ or the 'emphatic' /t̤/ as idiosyncratic. Other radiographic data of Iraqi pharyngeals (Delattre, cited in Hetzron 1969), do not show this maximum constriction. One may also interpret this as differences related to dialects.

4.6: Results of experimentation See Appendix I for tables of results.

The size and shape of the epiglottis varies, of course, from one person to another. In general, the epiglottis (see 2.2 for a description of the epiglottis) resembles a leaf with a narrow stem which widens towards the top end. This end curls towards the front. The whole epiglottis is flexible and moves backwards towards the back wall of the pharynx or downwards, where the tip may uncurl in some cases. It is interesting to find, however, that in spite of these variations, speech production is similar for these speakers. For instance, in the case of subject (JS), the vallecula or the space between the front

base or the underside of the epiglottis and the root of the tongue is not present. This may be due to the presence of a lingual tonsil, which is present in Ghazeli's (1977), cineradiographic tracing. Unfortunately, it was not possible to see the pharynx of subject (JS) with the fibreoptic endoscope. It seems that in the case of JS, the movement of the epiglottis is restricted. That is, because of the presence of a lingual tonsil, the movement of the epiglottis is only achieved as a result of the movement of the root of the tongue. This brings one to the question, is the movement of the epiglottis or the approximation of the top curled tip and the whole epiglottis to the back wall of the pharynx essential for the production of speech, and in particular, for the production of the pharyngeal sounds? JS's articulation of the pharyngeals is considered to be normal. Also, Ghazeli's description and acoustic findings prove that his pharyngeals /ħ/ and /ʕ/ may be considered normal. This may lead to the conclusion that the epiglottis only moves as a result of the movement of the root of the tongue, and because the pharyngeal sounds require a great pharyngeal constriction which is achieved mainly by the retraction of the root of the tongue towards the back wall of the pharynx and if the epiglottis has its curled tip, the top part will

eventually move towards the back wall of the pharynx, but in the other cases the movement is different. The gap between the epiglottis and the back wall of the pharynx seems to be different for (JS), compared with that for other subjects.

X-ray analysis

/ɰ/ in /ba:ɰ/, Figure 4.1

The tongue is slightly lowered from its position at rest, the root of the tongue retracts towards the back wall of the pharynx, narrowing the oropharyngeal cavity with the maximum constriction being between the epiglottis and the pharyngeal raphe. The larynx is raised, reducing the size of the oropharyngeal cavity. The jaw is lowered. The soft palate is raised, but the contact is only made partially, that is, only a small part of the soft palate seems to be in contact with the nasopharynx, the rest of the soft palate seems to be well away from the nasopharynx.

/3/ in /ba:3/, Figure 4.2

There is very little change in the shape of the tongue for /3/ as compared to /ɰ/. The displacement is only apparent for the root of the tongue horizontally, and not for the body of the tongue vertically. The constriction of the root of the tongue and the back wall of the pharynx

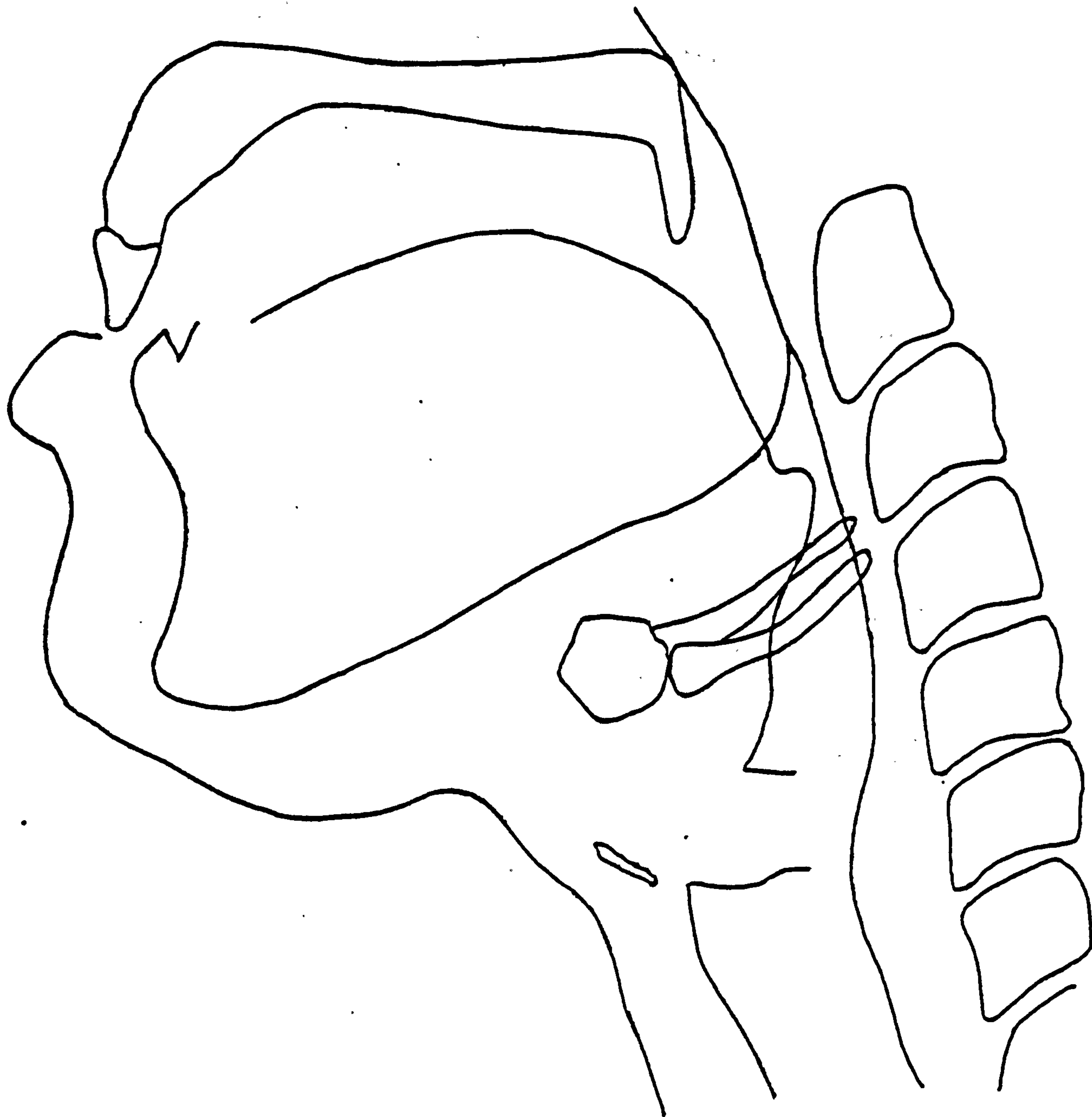


Figure 4.1 /ʌ/ in /ba:ʌ/ (JS)

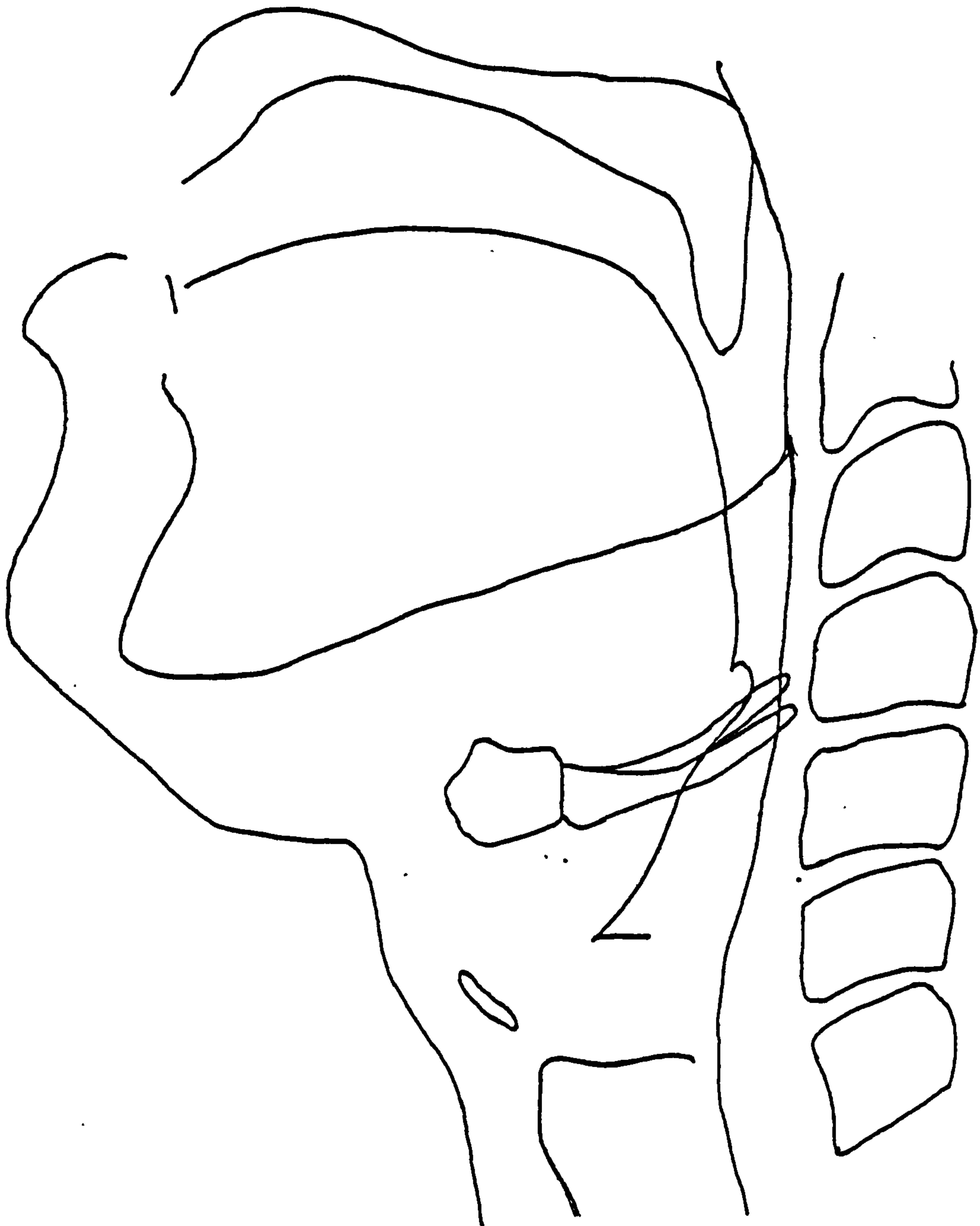


Figure 4.2 /3/ in /ba:3/ (JS)

is greater at the level of the epiglottis, but not as great as that for /ɰ/. The laryngo-pharyngeal cavity appears to be smaller for /ʒ/ than for /ɰ/, due to the fact that the larynx is raised higher for /ʒ/ than for /ɰ/. The hyoid bone does not appear to be displaced. The jaw is lowered. The nasal tract seems to be partially closed with a closure similar to that for /ɰ/, though the contact seems to be a little firmer for /ʒ/ than it is for /ɰ/.

Xeroradiographic analysis

Analysis of lateral xeroradiograms of /ɰ/ in /naɰna/ and /ʒ/ in /maʒʒana/ as said by WL, Figures 4.3 and 4.4, shows that the narrowest point of constriction between epiglottis and back wall of the pharynx takes place at the level of about 5 mm lower from tip of epiglottis for both /ɰ/ and /ʒ/. However, because the larynx is raised a little higher for /ɰ/ than for /ʒ/, the difference is merely 3 mm. The epiglottis tends to have a slightly different shape in either case in relation to that of rest. The constriction in the vallecula, as a result of the raising of the larynx and, at the same time, the lowering of the root of the tongue bunches up the epiglottis and shortens the area between tip of epiglottis and vallecula which is about 8 mm for /ɰ/ as regards 12 mm for /ʒ/. As a result of the constriction in the vallecula area, the distance



Figure 4.3 /3/ in /ma33ana/



Figure 4.4 /ɰ/ in /naɰa/ (WL)

between base of epiglottis and epiglottic vallecula is 1 mm for /3/ and 4 mm for /ɰ/. The distance at the level of the median glosso-epiglottic fold is 5 mm for /3/, and 4 mm for /ɰ/. And at the level of the pharyngeal surface of tongue and tip of epiglottis, it is 7 mm for /3/ as regards 5 mm for /ɰ/.

The xeroradiogram of /3/ in /ma33ana/ shows a lowering of the soft palate. This is not surprising, due to the presence of a nasal sound in the utterance. What is surprising, is the absence of this feature in the xeroradiogram of /ɰ/ in /naɰna/, though there is a nasal consonant in this utterance as well. Is it that the action of lowering the soft palate is relinquished immediately after the articulation of the nasal and possibly the vowel, hence the closure of the soft palate for /ɰ/? The closure, ^{soft palate} nevertheless, is not tight and only part of the epiglottis [?] is in contact with the back wall of the pharynx. As for /3/, the distance between the soft palate and the back wall of the pharynx is about 5 mm at the bottom, as regards to about 1 mm for /ɰ/. Investigation of nasal airflow showed that there is nasal airflow for /ɰ/ and /3/, whether there is a nasal sound in the utterance or not with more nasal airflow for /ɰ/ than for /3/.

The narrowest distance between tongue root and back wall of pharynx takes place at the level of the base of the

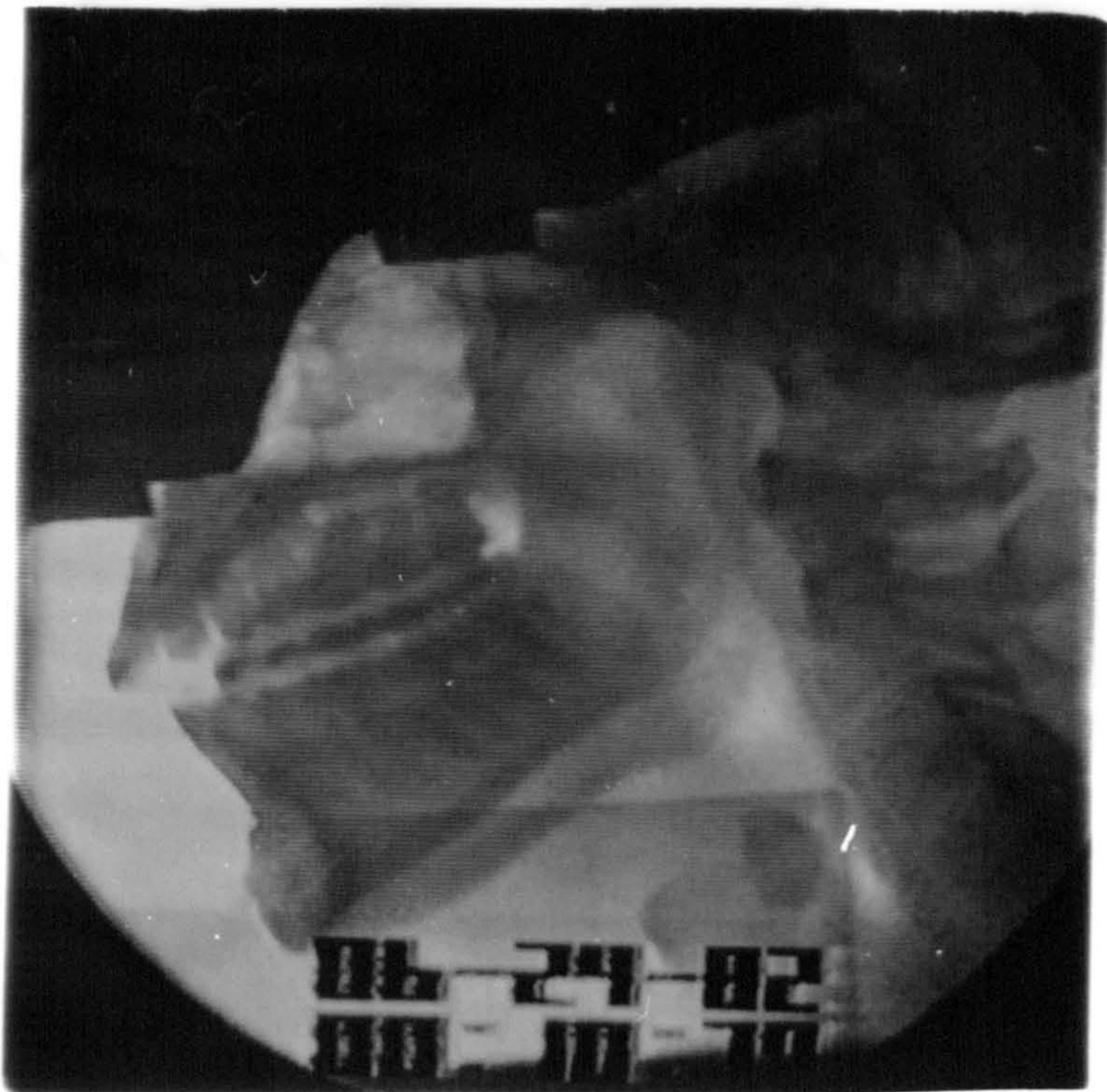
epiglottis for both /ʁ/ and /ʒ/, and measures 10 mm in both cases against C2, though a little higher for /ʁ/ than for /ʒ/.

As for the hyoid bone, it tends to move backwards towards the back wall of the pharynx for /ʁ/, 43 mm as regards 40 mm for /ʒ/, with the horns slightly raised for /ʁ/ than for /ʒ/. In both cases, the horns are pointing towards C3.

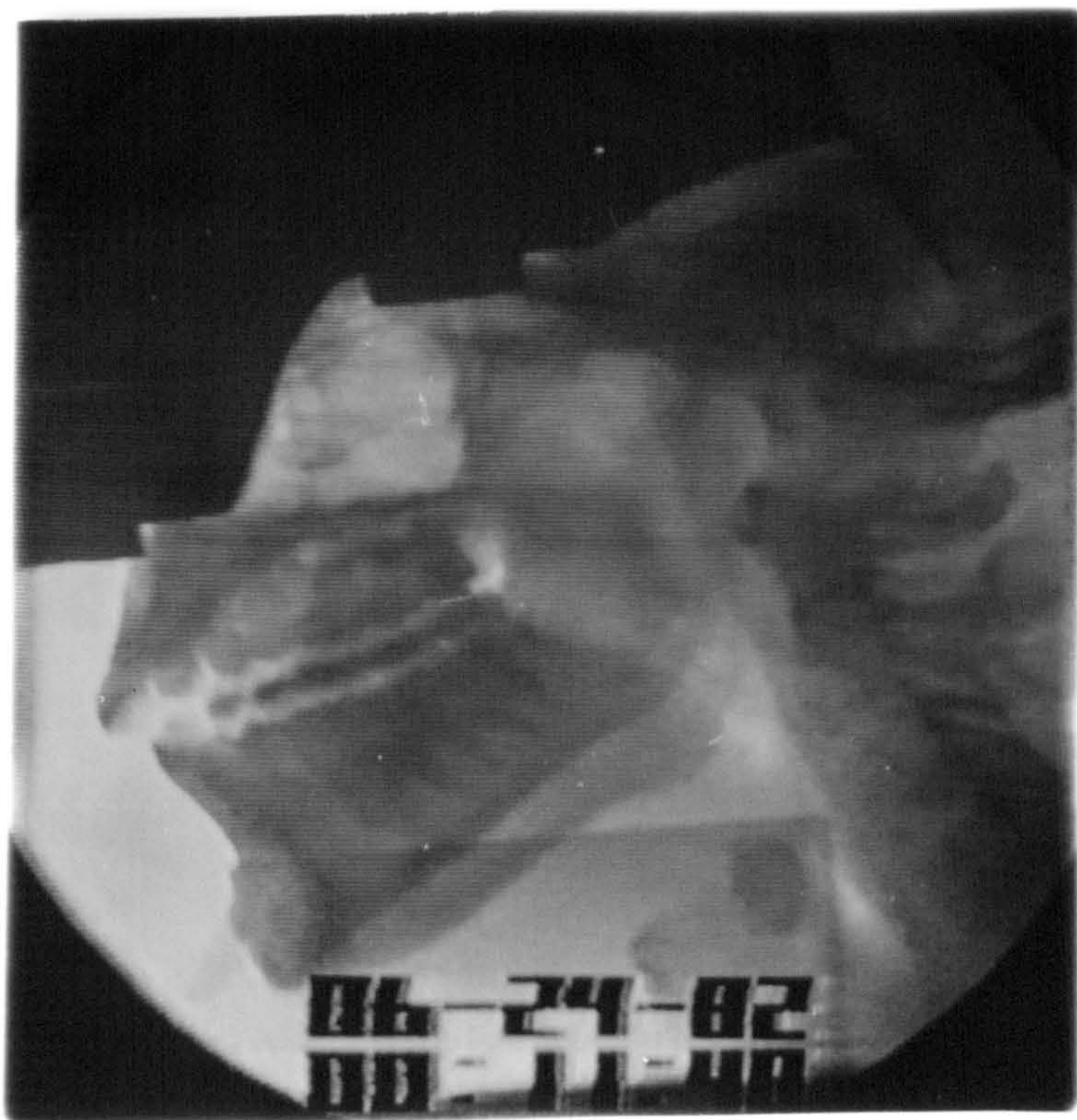
The body of the tongue bunches up slightly against the line between hard palate and soft palate. The tip of the tongue rests against the lower teeth. The lips are neutral, but the mouth is open as a result of the presence of an open vowel in the two words.

Videofluorographic analysis

Figure 4.5.a and b are of /ʒ/ in /ʒi:d/ and /ʒ/ in /ʒu:d/. The two illustrations show that the soft palate is lowered in spite of the absence of a nasal sound in the two utterances. The initial position of the voiced pharyngeal /ʒ/ may explain why the soft palate is lowered. Because the pharyngeals, in general, tend to have a lowered soft palate and because /ʒ/, in these examples, occurs in word-initial position, that is, after a pause or a rest, where the soft palate is lowered, or for inspiration, it is possible that the soft palate is maintained in the



a. /3/ in /3i:d/ (FL)

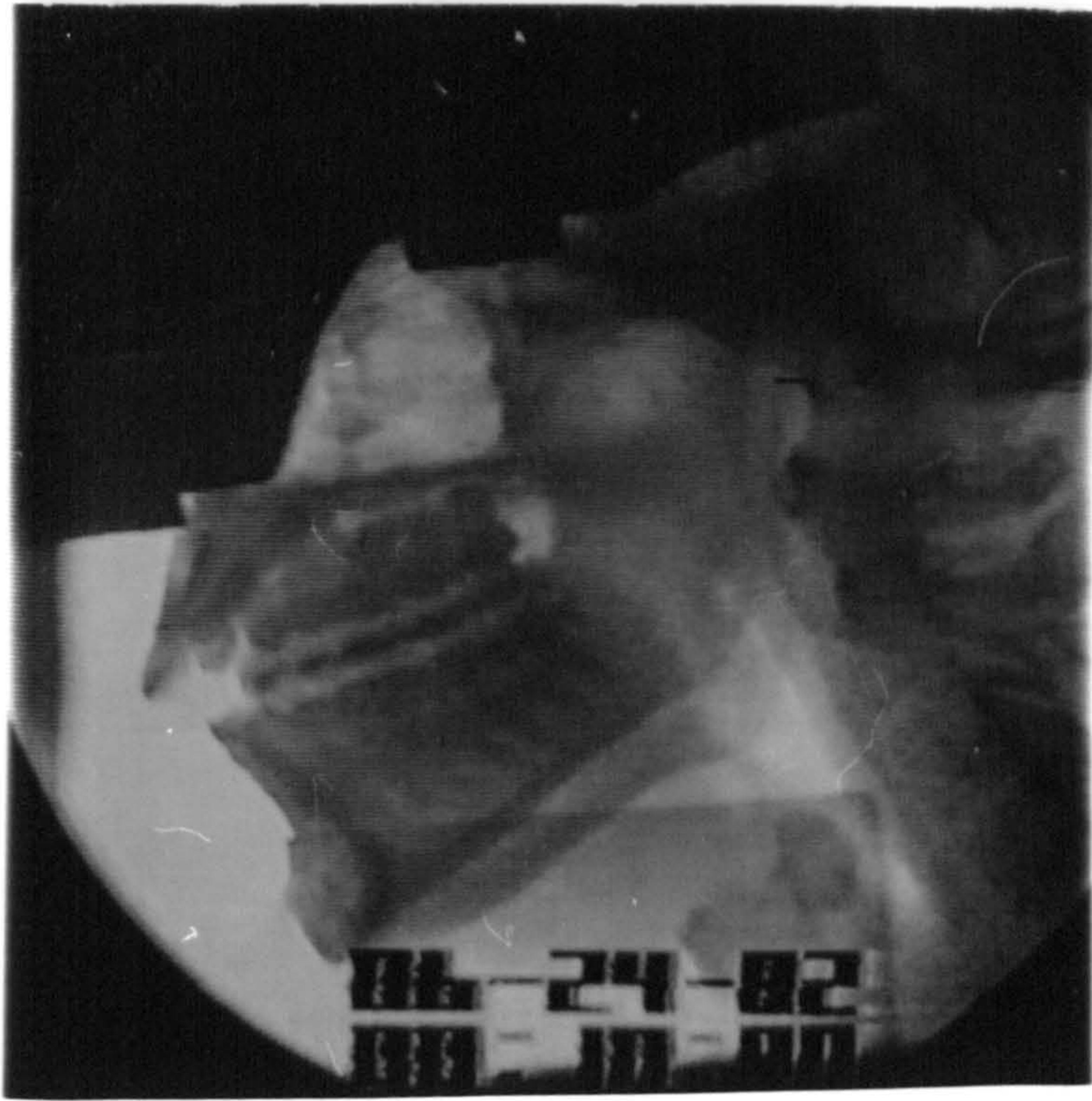


b. /3/ in /3u:d/ (FL)

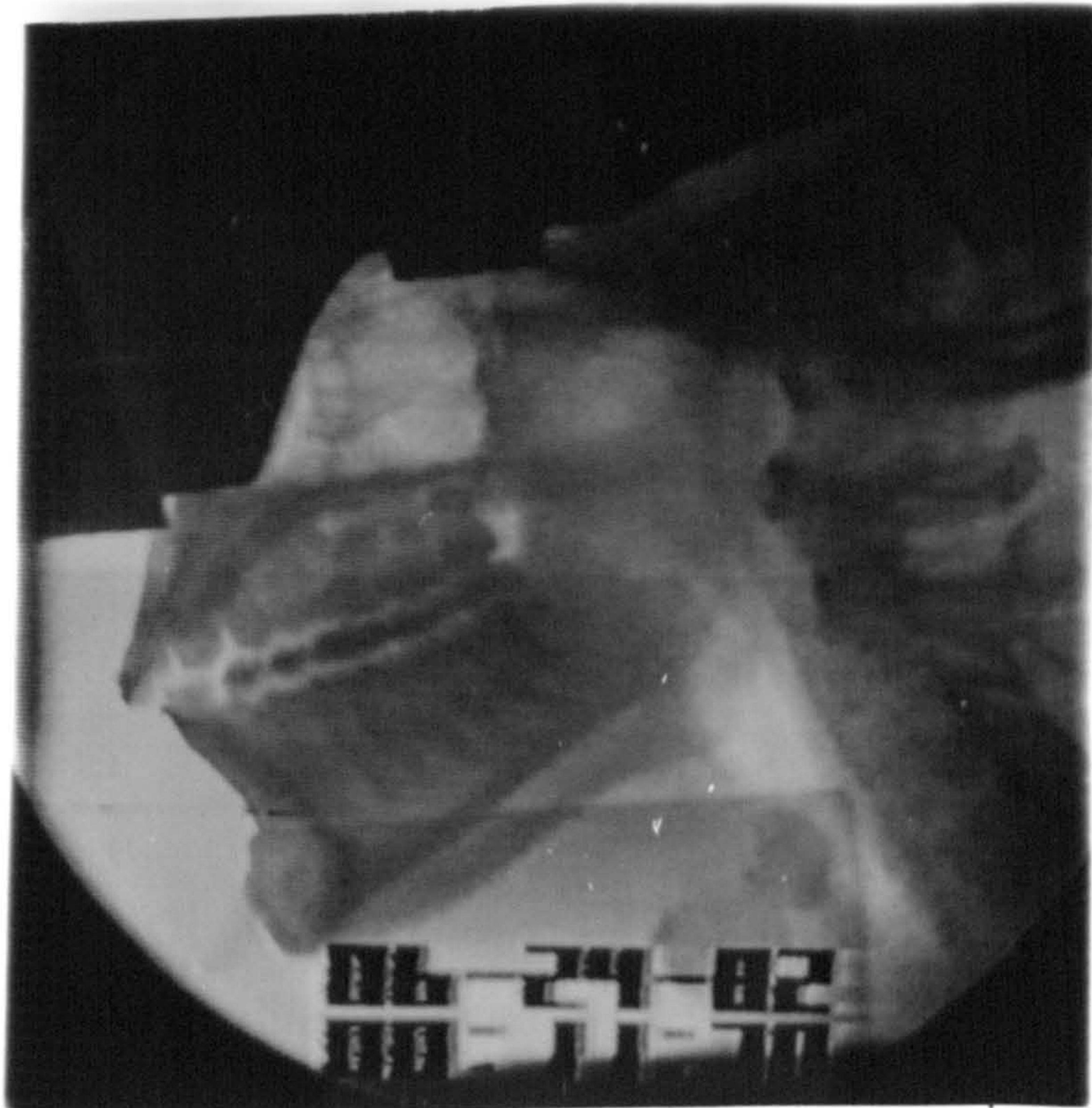
lowered position even during /ʒ/. During the /ʒ/ in /ʒi:d/, the tongue is taking up the position for the vowel /i:/. The root is grooved just above the epiglottis. The epiglottis and the tongue root are retracted and very near the back wall of the pharynx. The dorsum of the tongue is raised towards the soft palate and the whole body of the tongue is raised. For /ʒ/ in /ʒu:d/, the root of the tongue and the epiglottis are retracted and the dorsum is retracted and raised towards the tip of the soft palate. In both examples, the positions of the articulators show anticipation of the following vowels. These features can be easily seen on the film.

Figure 4.6.a and b of /i:/ in /ʒi:d/ and /u:/ in /ʒu:d/ respectively. The soft palate is raised, and the epiglottis and the root of the tongue are not retracted towards the back wall of the pharynx, showing that the influence of the pharyngeal /ʒ/ is small. The body of the tongue is raised and slightly retracted for /u:/. It is interesting to see the depression in the root of the tongue in both examples.

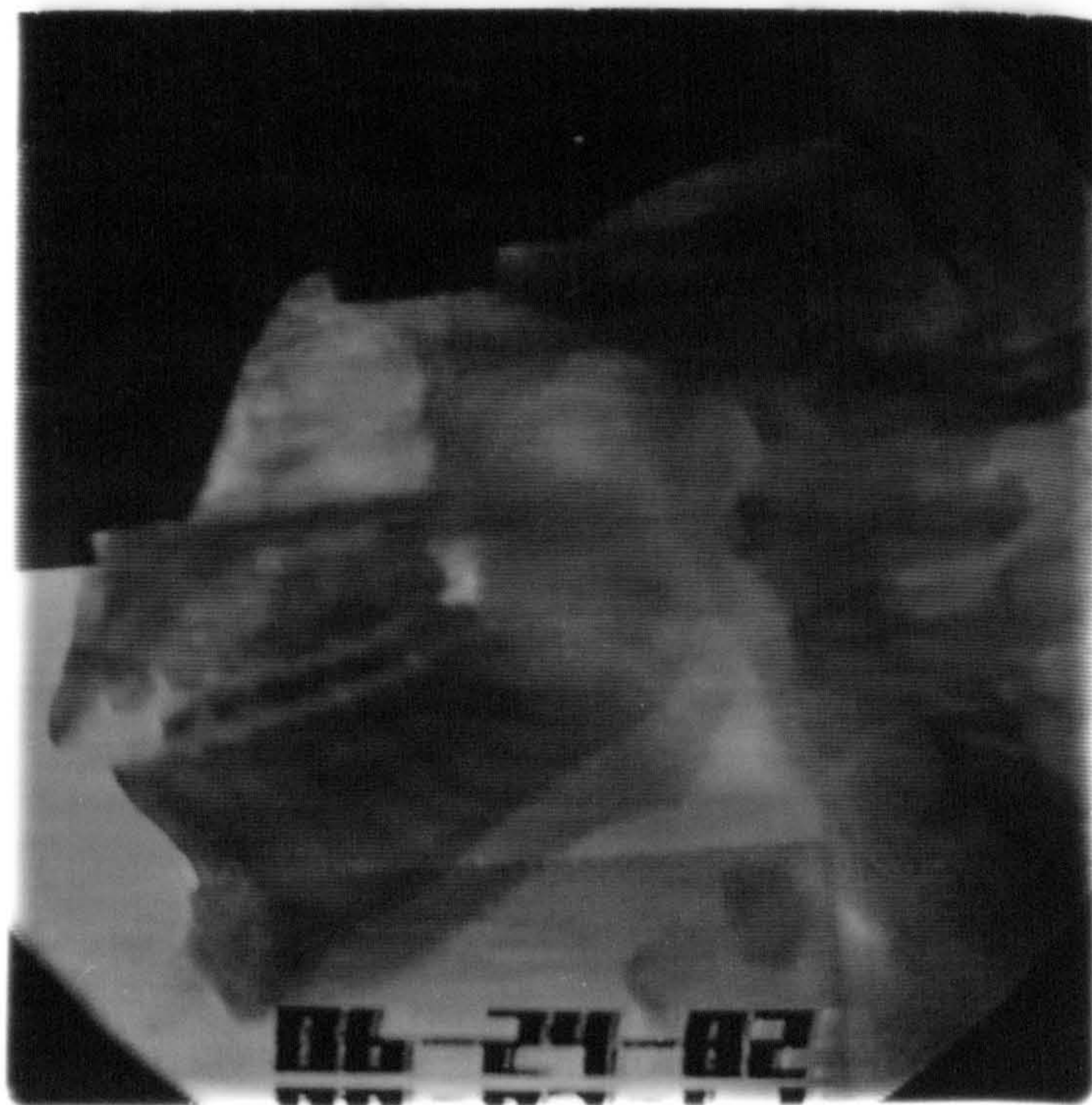
The examples of /ħ/ in /ħilim/ and /ʒ/ in /ʒilim/, Figures 4.7.a and b respectively. The constriction in the pharynx is greater for /ħ/ than it is for /ʒ/. The soft palate has a more lowered position for /ʒ/ than for /ħ/. In both cases it is lowered. Figures 4.8.a and b of /i/ in /ħilim/ and /ʒilim/ preceded by the pharyngeals /ħ/ and /ʒ/,



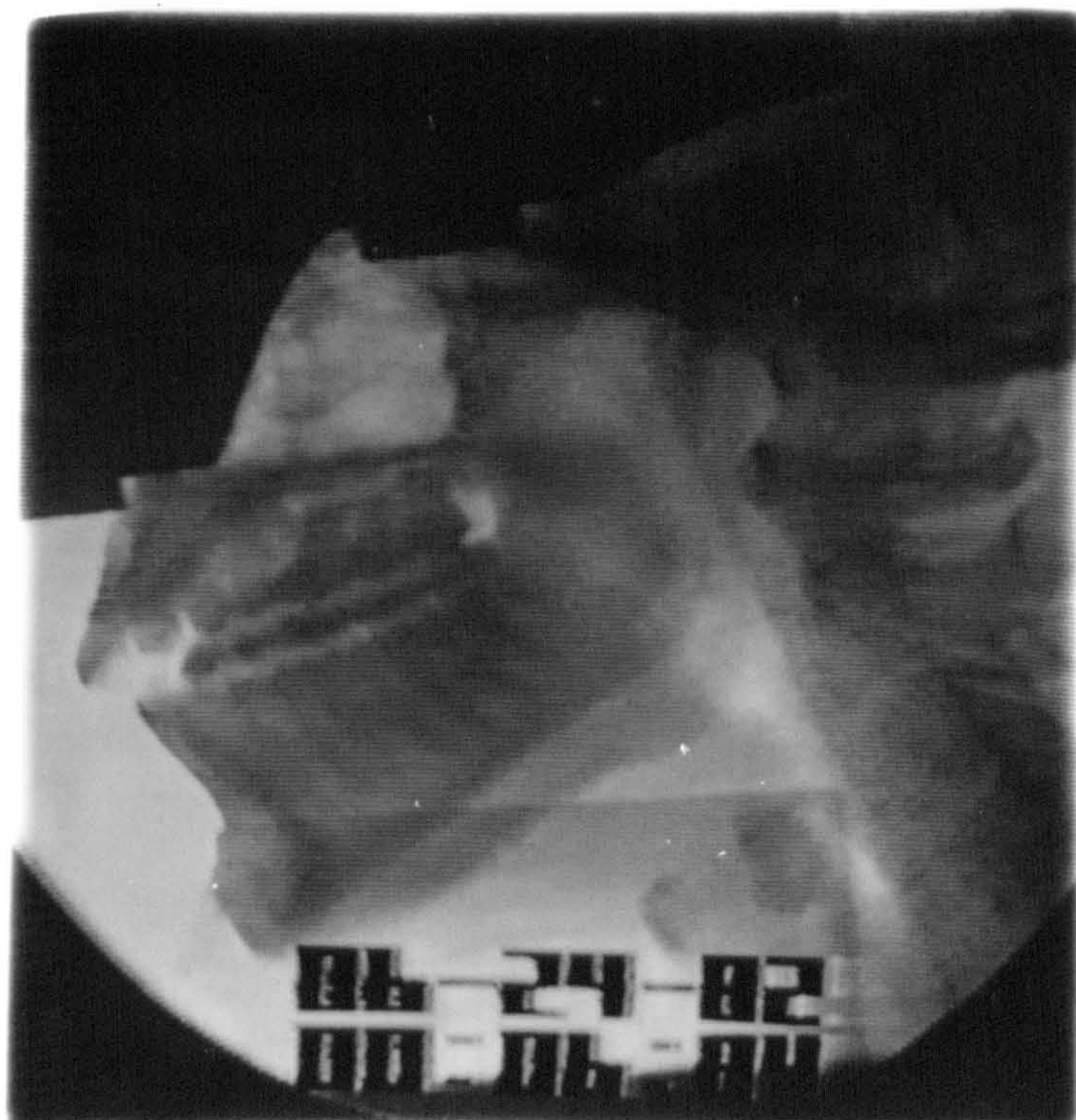
a. /i:/ in /ʒi:d/ (FL)



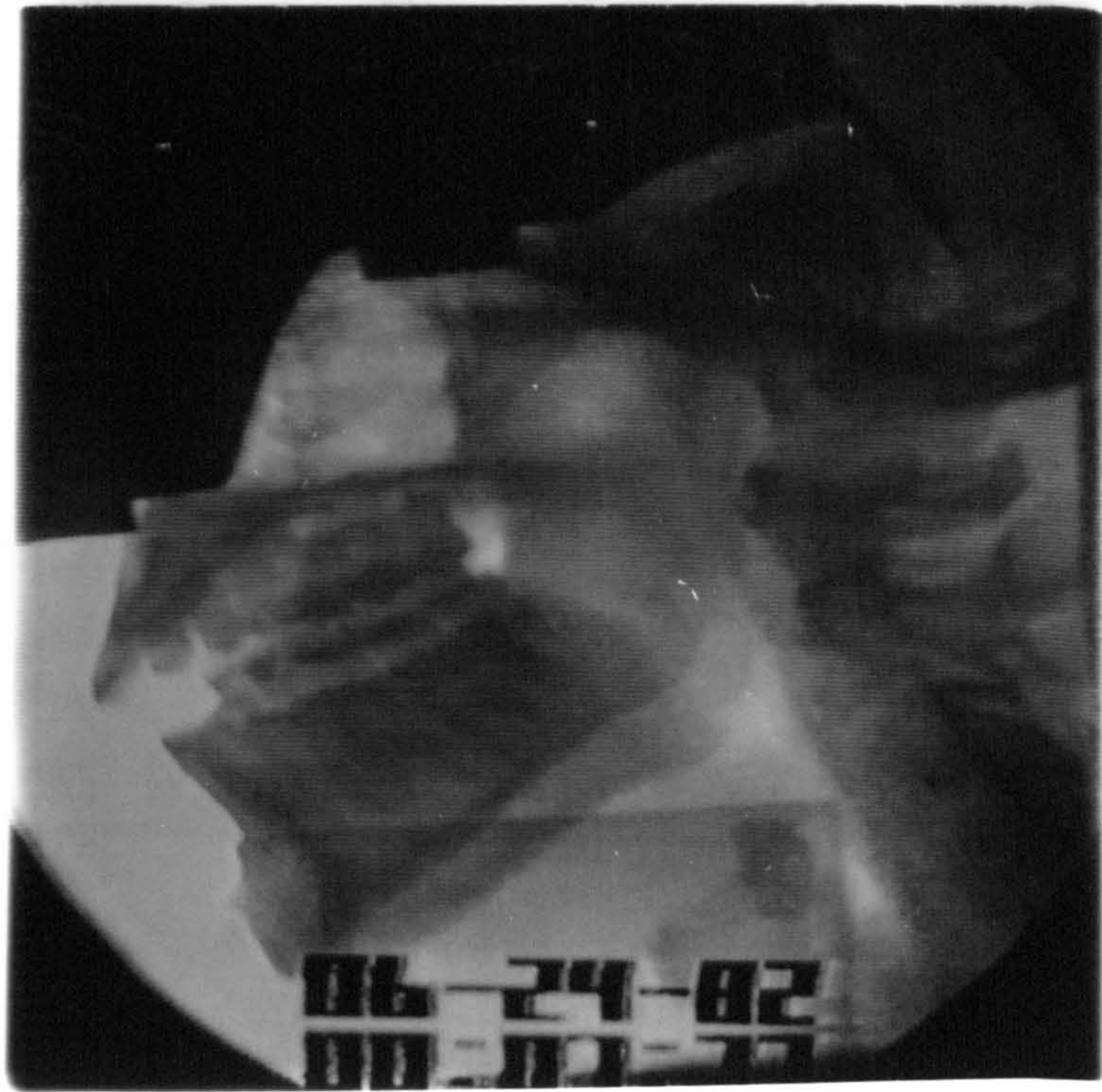
b. /u:/ in /ʒu:d/ (FL)



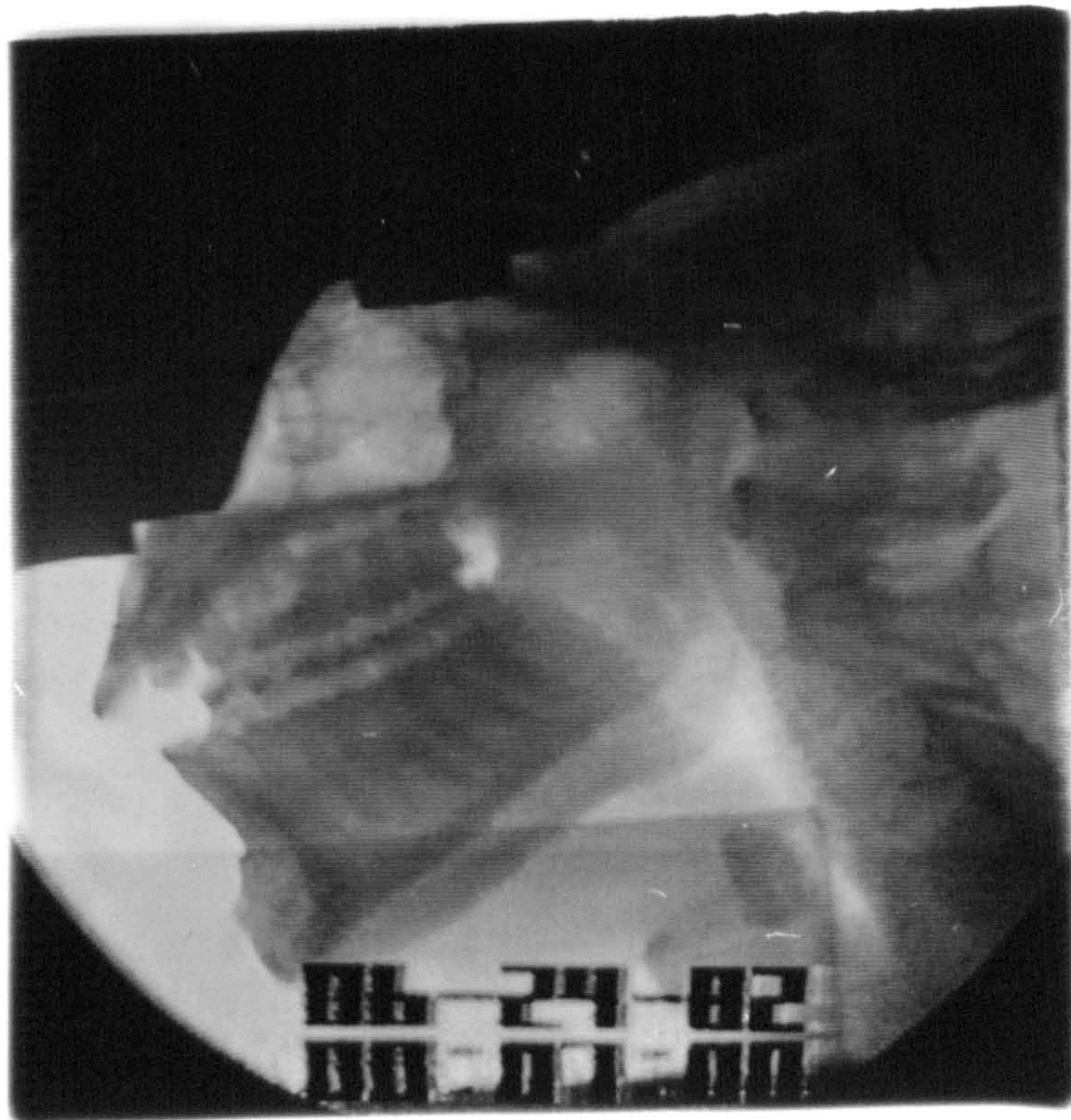
a. /ʎ/ in /ʎilim/ (FL)



b. /ʒ/ in /ʒilim/ (FL)



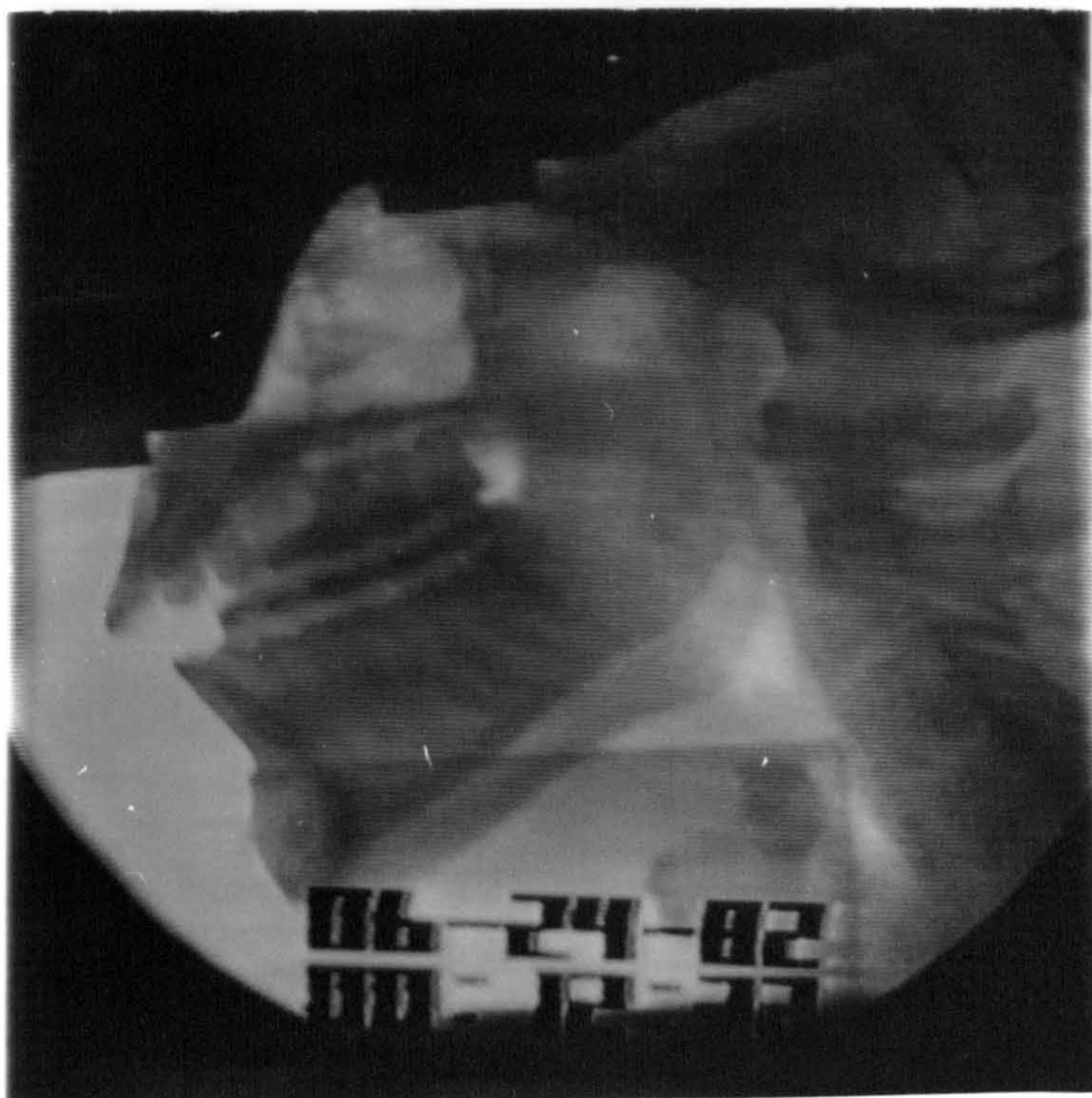
a. /i/ in /vilim/ (FL)



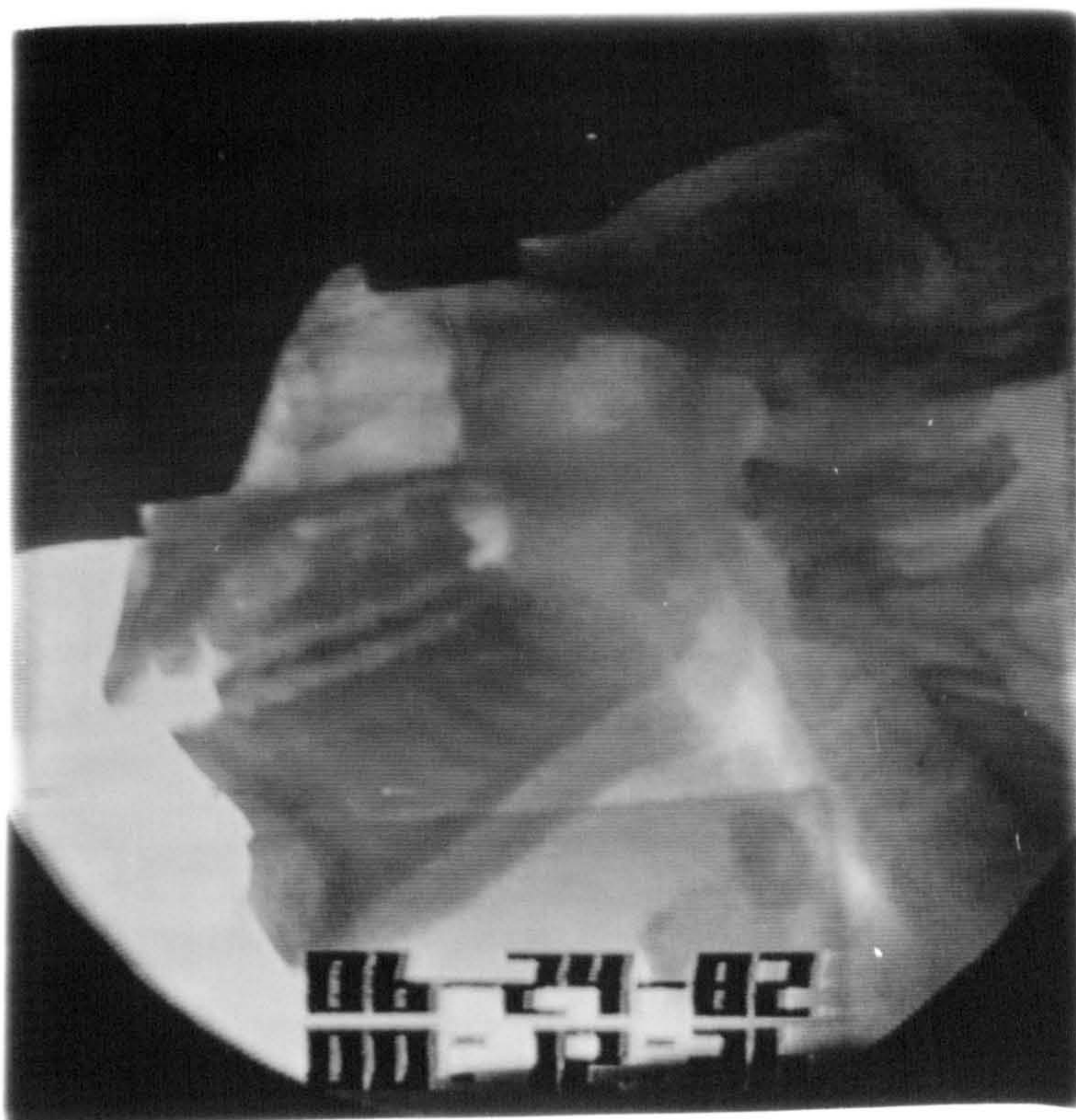
b. /i/ in /zilim/ (FL)

show that the soft palate is raised, thus confirming the view that the soft palate lowering for the initial pharyngeal consonants is not due to the presence of a nasal sound in the utterance, but for other reasons. The root of the tongue and the epiglottis take up their retracted position for /ʕ/ and /ʕ/, though not in the same degree. The dorsum and the body of the tongue are drawn forward and upward. The larynx is not as raised as it is for the other examples.

It seems that for the articulation of the adjacent vowels, the root of the tongue slightly leaves its position for the articulation of the pharyngeals, that is, it moves forwards while the rest of the tongue takes the shape to produce the vowel. In the case of /ʕ/, the tongue root moves forwards slightly, but this forward movement is more for the close front or back vowels. Figures 4.9.a is of /ʕ/ in /ʕe:t/. The epiglottis with the root of the tongue are retracted against the back wall of the pharynx. The soft palate is raised, but is not firmly in contact with the back wall of the pharynx. The view of /e:/, Figure 4.9.b, in the same word is similar to that of /ʕ/, except that the constriction in the pharynx is less in /e:/ than in /ʕ/. The epiglottis is a little distance away from the back wall of the pharynx. In /ʕadd/, the soft palate is almost in contact with the back wall of the pharynx. The constriction is low down in the pharynx, though not very narrow. The



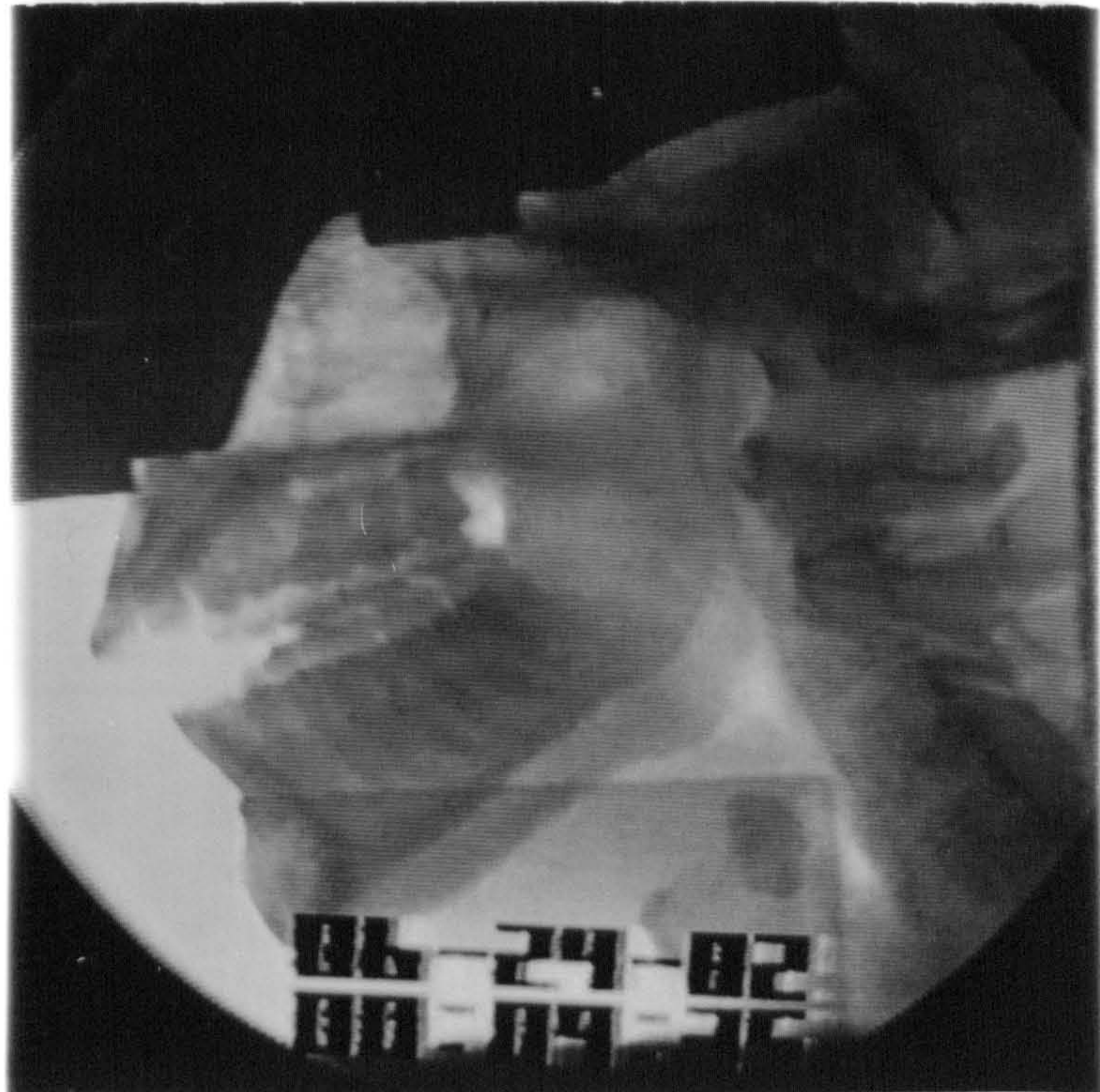
a. /~~u~~/ in /~~u~~e:T/ (FL)



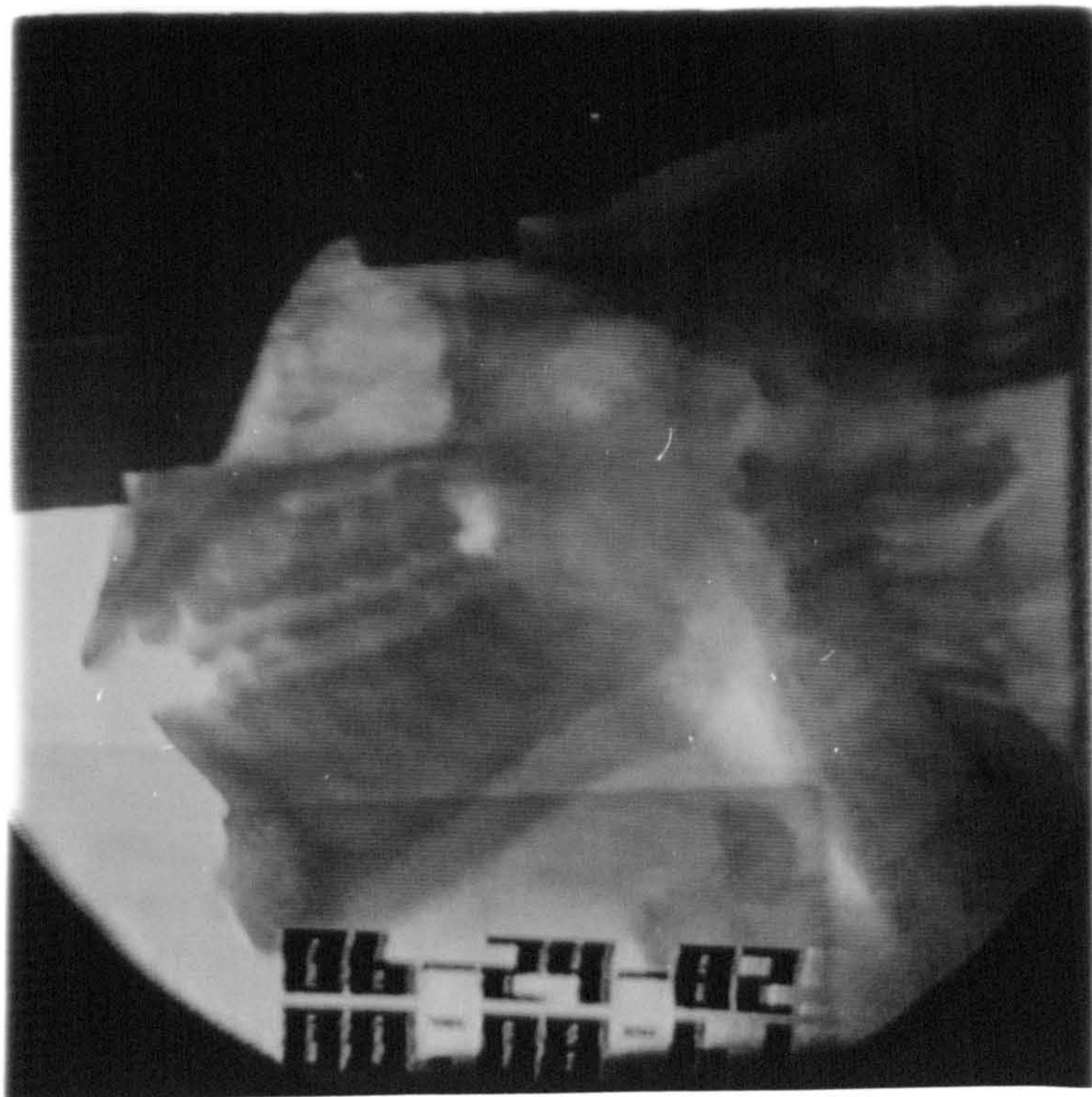
b. /e:/ in /~~u~~e:T/ (FL)

larynx is not much raised. All these show the view is either just before or after the maximum constriction for /ɣ/. The jaw is lowered.

Figure 4.10.a and b shows the position of the articulators for the vowel /a/ in /ɣadd/ and /ʒadd/ respectively. The constriction in the pharynx is great for /a/ adjacent to /ɣ/ almost similar to the constriction for the pharyngeal itself. In /ʒadd/, the constriction is wider. In both cases, the constriction is at its maximum at the level of the epiglottis. The larynx is raised in both examples. The soft palate does not seem to have the bunched up position in /ʒadd/ as it has in /ɣadd/. In /sama:ʒ/, Figure 4.11.b, the soft palate is lowered, undoubtedly, due to the presence of a nasal in the utterance. In /sama:ɣ/, Figure 4.11.a, the epiglottis is close to the back wall of the pharynx, though not as close as in /sama:ʒ/, which seems almost to touch it. Looking at the pharynx through the endoscope, one can see a gap which appears a little wider when the subject says the word in a low pitch voice. The root and dorsum of the tongue flatten and tend to move forward, creating a wide cavity above the epiglottis level. It is most probably that the exposure for /ɣ/, Figure 4.11.a was taken either just before or after the instant of maximum constriction. The soft palate is slightly lowered for /ɣ/ in /sama:ɣ/.

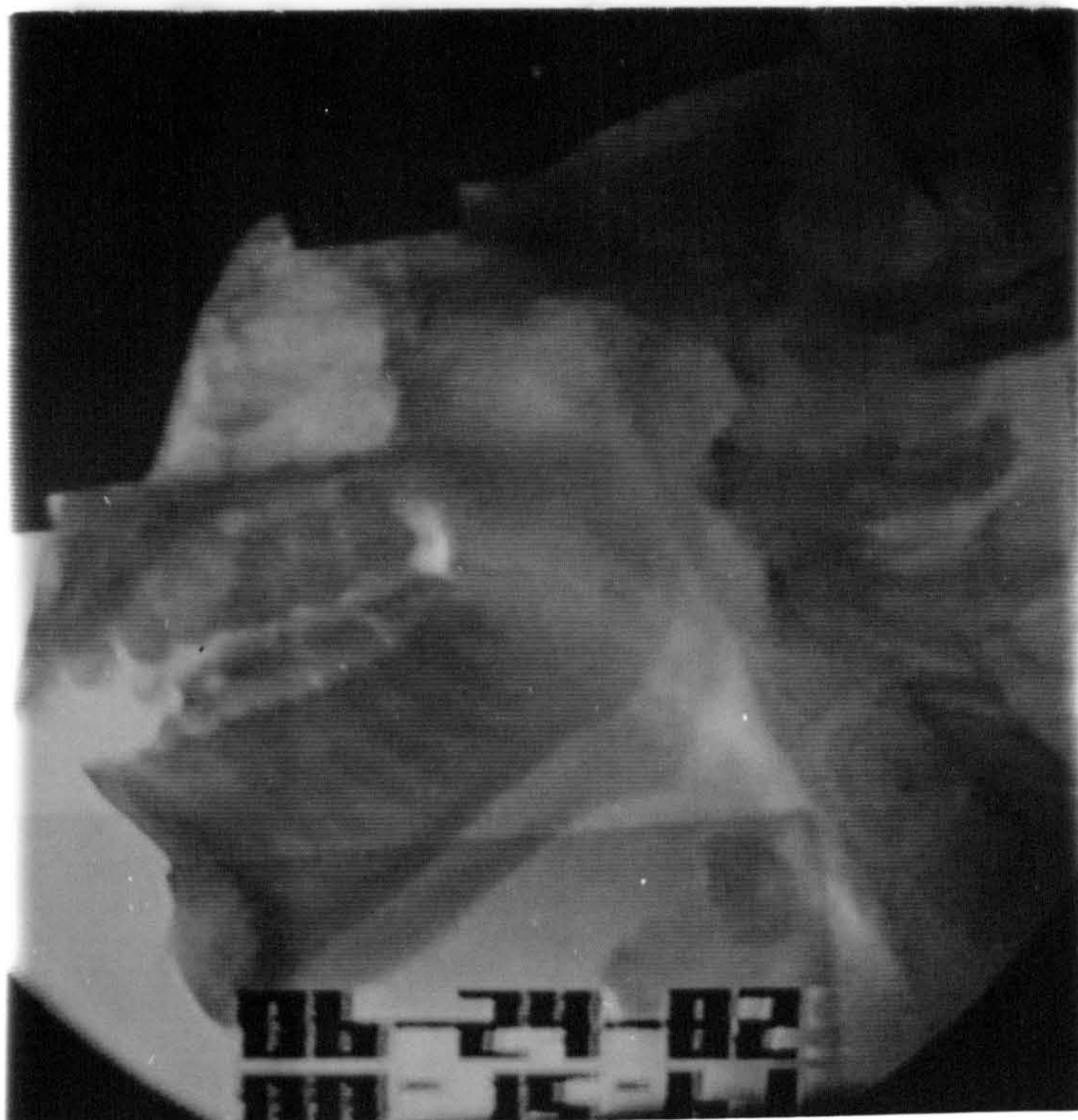


a. /a/ in /ʌadd/ (FL)

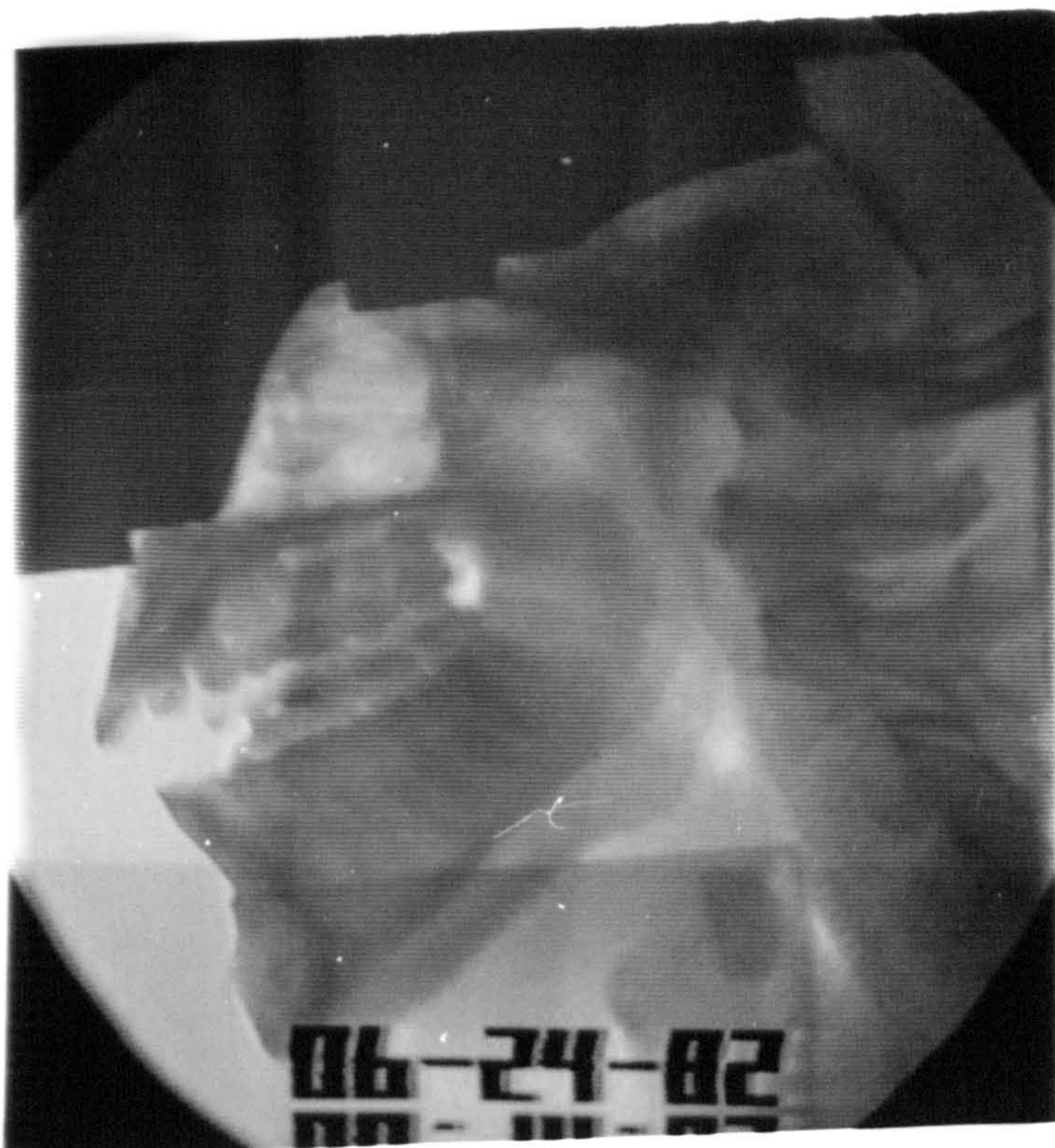


b. /a/ in /ʒadd/ (FL)

Figure 4.10



a. /ʏ/ in /sama:ʏ/ (FL)

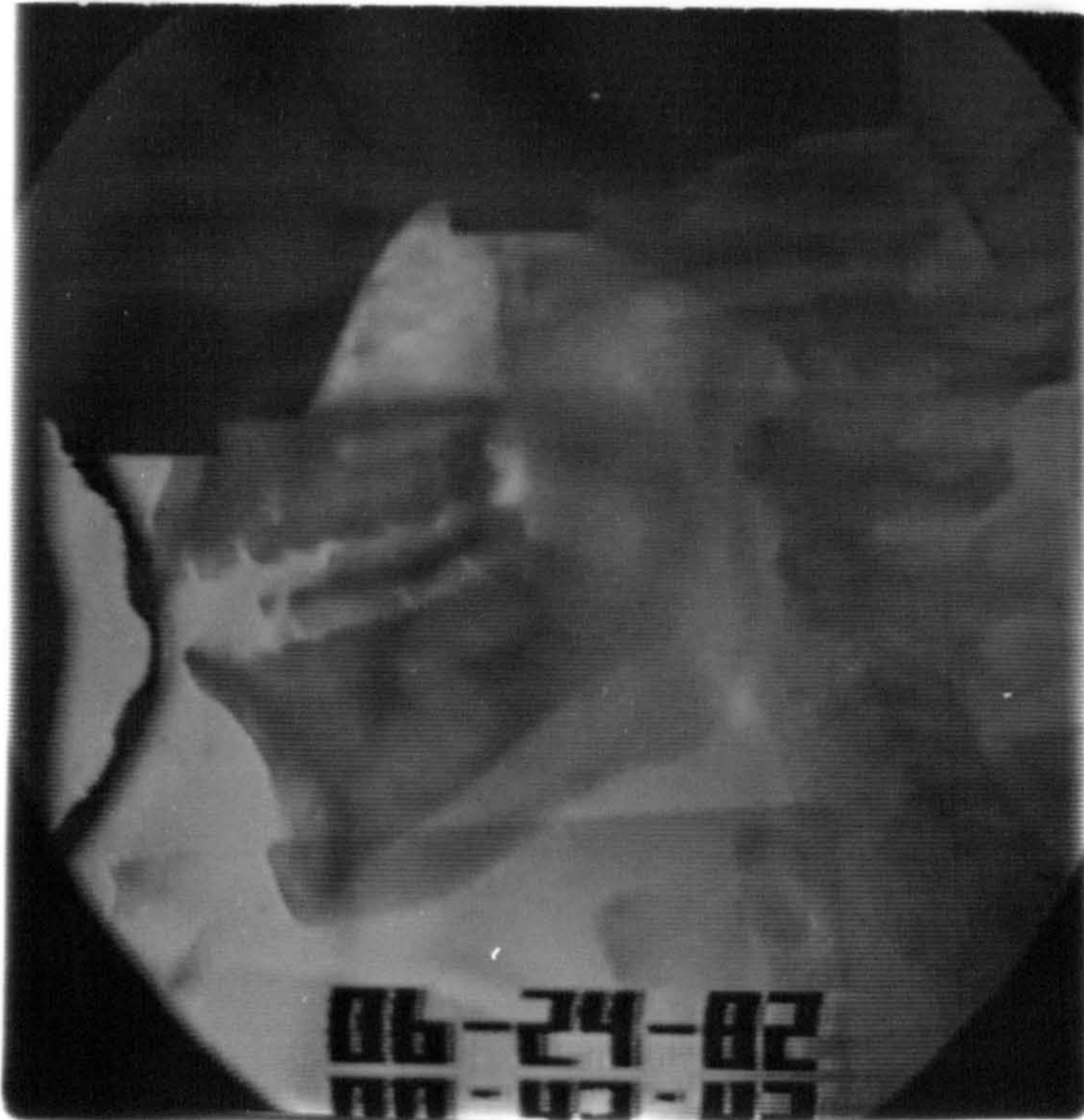


b. /ɜ/ in /sama:ɜ/ (FL)

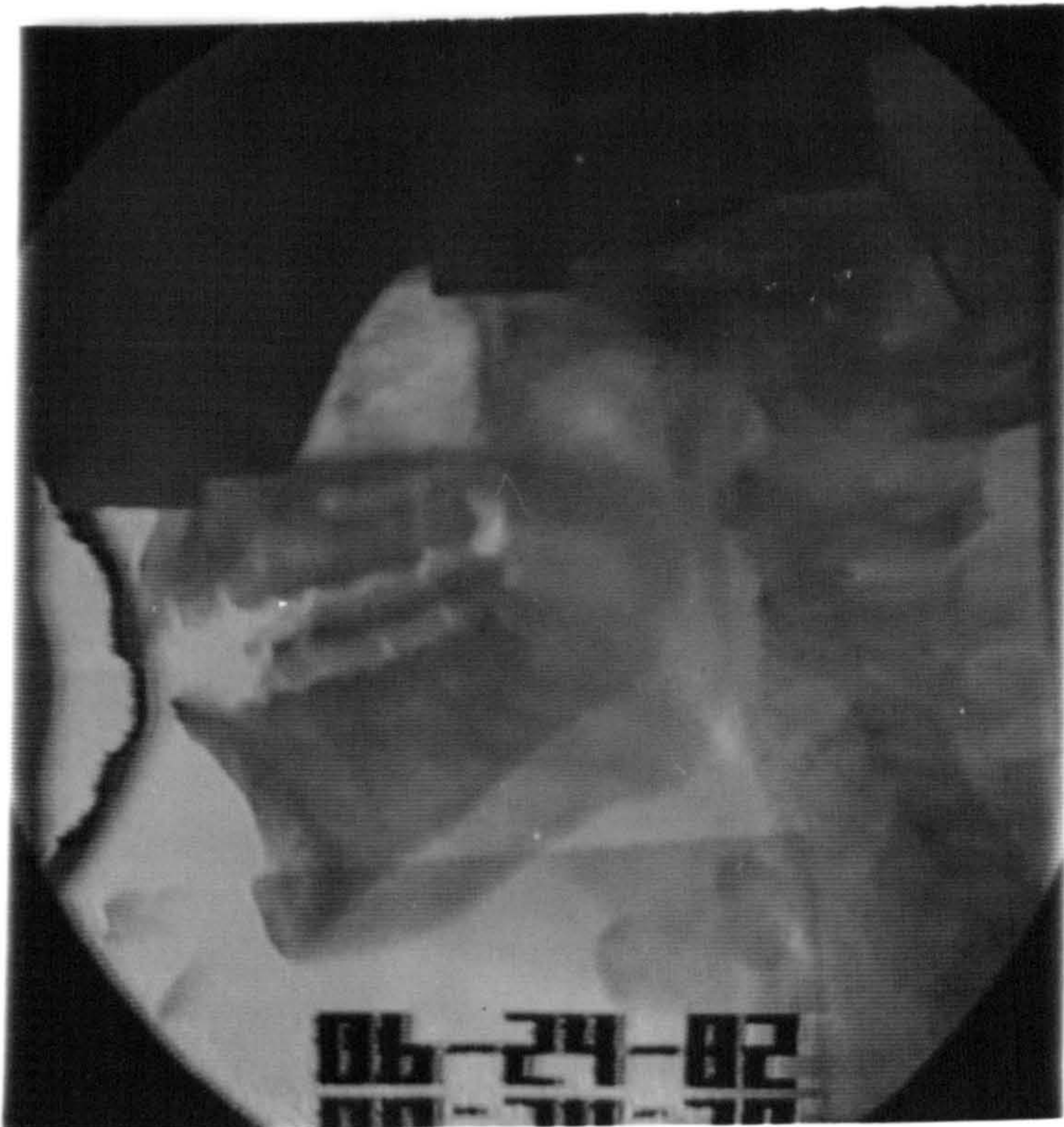
One can compare this view to that of /ʔ/ in /sama:ʔ/, where the constriction in the pharynx is wider than that for /ʒ/, but still quite narrow at the level of the epiglottis; this may be an influence of the open vowel /a:/. The shape of the tongue is, however, much the same and this may be because both examples have the same vowel adjacent to the final consonant. The soft palate is also lowered.

In /raħa/ and /raʒa/, Figures 4.12.a and b. a. is of the maximum point of constriction for /ħ/, where this constriction seems to extend along the whole area of the level of C3. There is a very narrow gap between the soft palate and the back wall of the pharynx, but this is not unusual in the context of two open vowels. The tip of the soft palate curls forward in the first example and almost rests on the tongue. In both examples, the larynx is raised. The jaws are open. In the second example, the epiglottis and the root of the tongue start to leave the back wall of the pharynx, the soft palate lowers more, but the tip uncurls slightly.

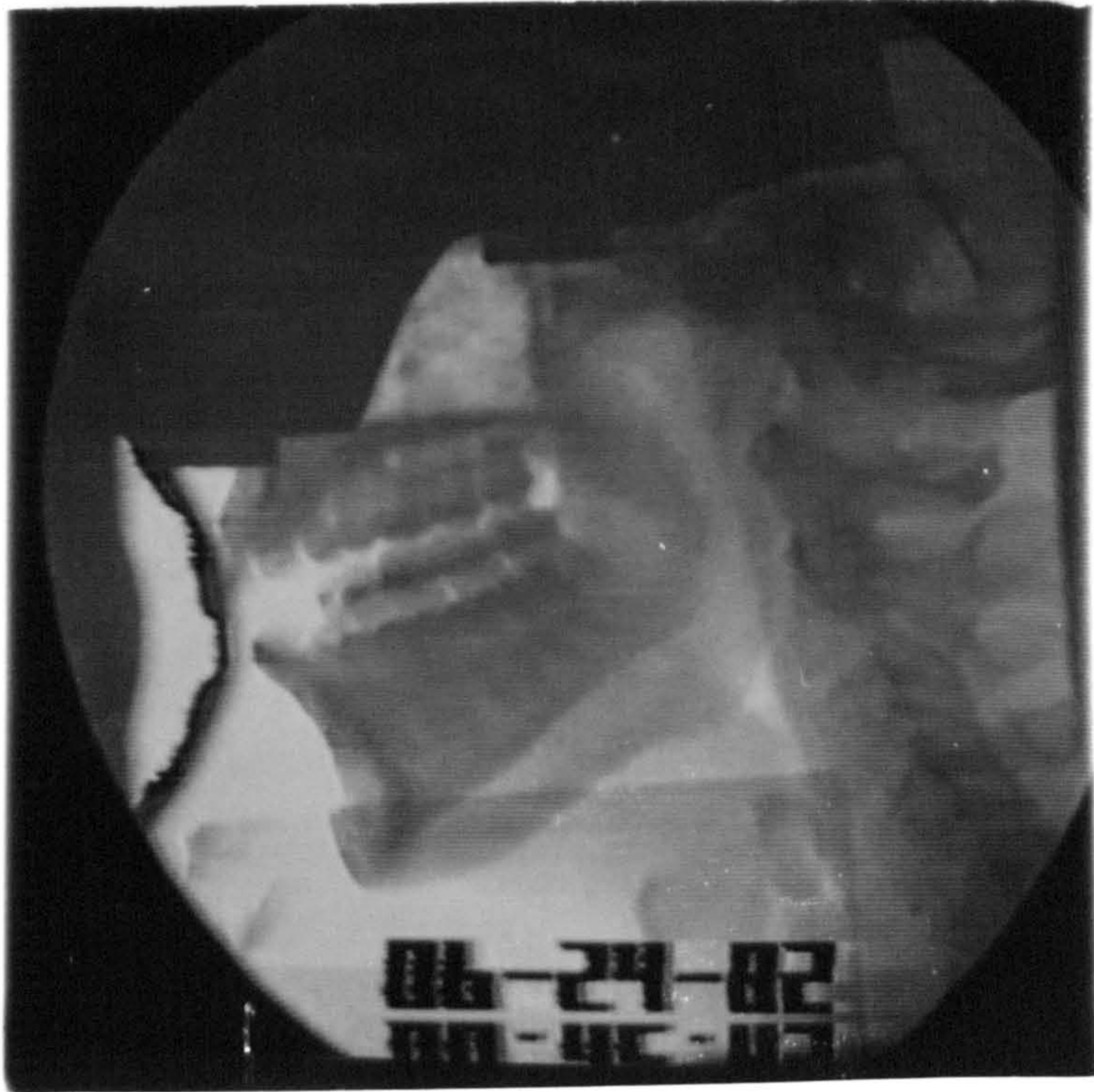
Figure 4.13.a is of the pharyngeal /ʒʒ/ in /maʒʒana/. The constriction is very great at the level of the epiglottis against the back wall of the pharynx and though a complete closure is not effected, a narrow gap can be observed. The larynx is raised and the larynopharyngeal area



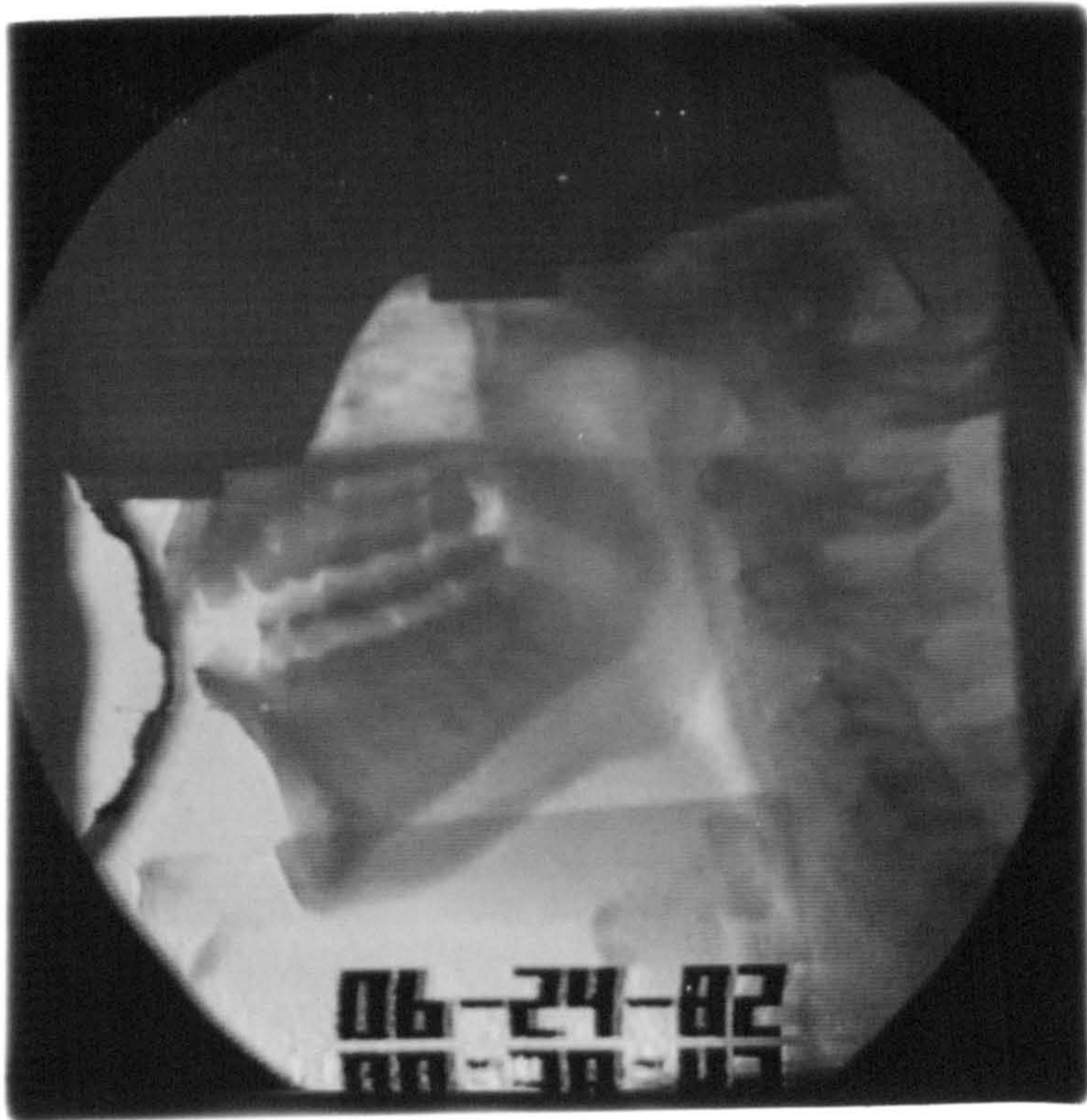
a. /ʎ/ in /raʎa/ (FL)



b. /ʒ/ in /raʒa/ (FL)



a. /33/ in /ma33ana/ (FL)



b. /3/ preceded by /33/ in /ma33ana/ (FL)

seems to be very small. The soft palate retains its position for the nasal as the gap is almost as large as that for a nasal. The body of the tongue is pushed forward in the mouth.

Figure 4.13.b is of /a/, preceded by the pharyngeal /ʕ/ in /maʕʕana/. The constriction in this example is not as great as for /ʕ/. The larynx is raised and the soft palate is lowered, though slightly less than for /ʕ/.

Endoscopic analysis

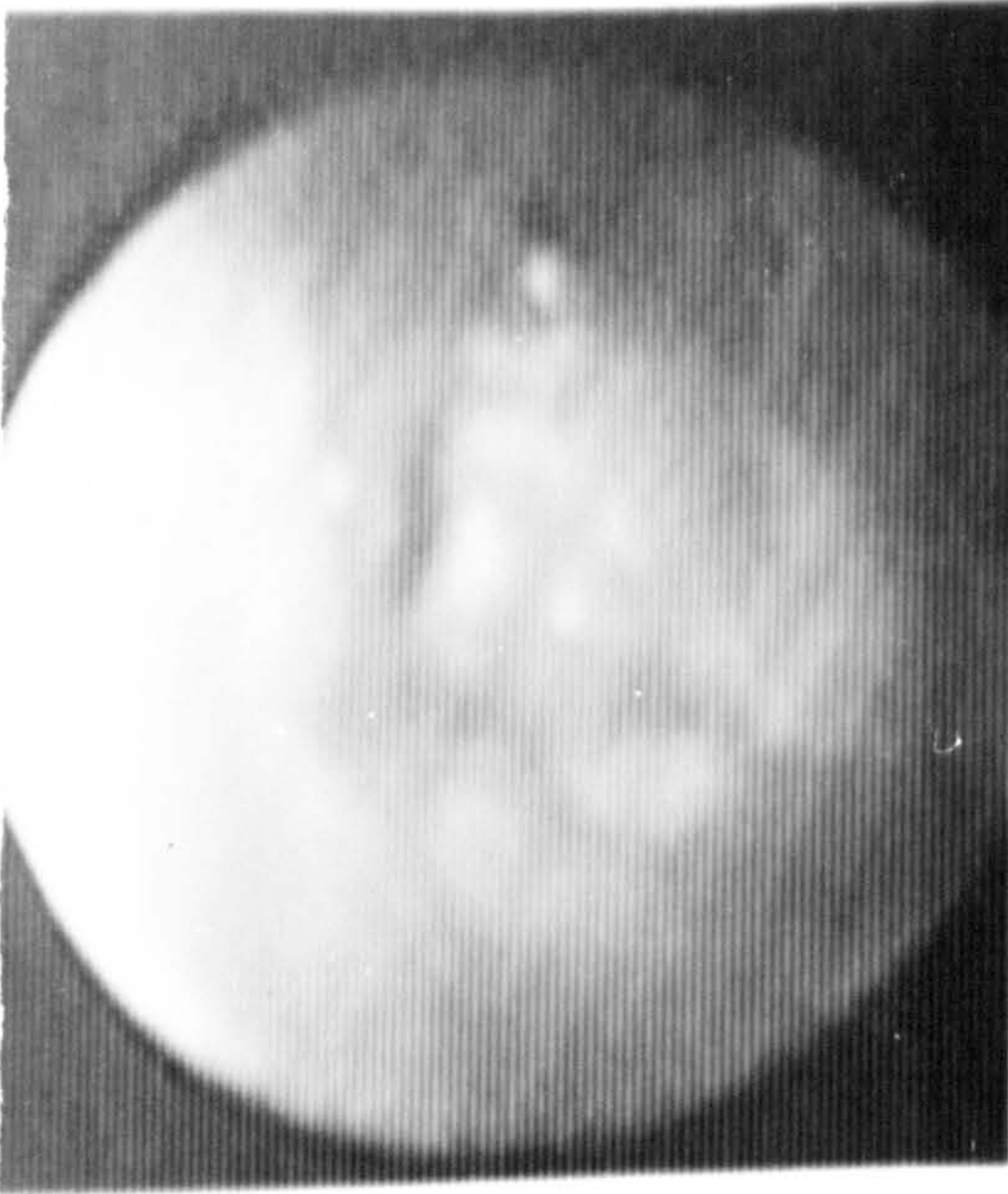
Laufer and Condax (1979, 1981), were the first to use fibreoptic endoscopy to study the articulation of the pharyngeal consonants /ħ/ and /ʕ/ in Hebrew, and to establish the epiglottis as the articulator for these sounds. However, this method cannot suffice on its own to give conclusive findings; other experimental techniques have to be used also. Laufer and Condax supported their endoscopic study by spectrographic analysis, aerodynamic measurement and the study of the anatomy of that area of the pharynx.

The endoscopic technique, to study the pharyngeal sounds in Arabic for this thesis gave generally similar findings to those of Laufer and Condax.

Endoscopic observation of the pharyngeal cavity - during the articulation of pharyngeal and other sounds is generally described in relation to the 'at rest' position. The upper edge of the epiglottis in the 'at rest' position is curled considerably, and the gap between itself and the back wall of the pharynx is wide.

When the pharyngeal sounds /ʁ/ or /ʒ/ are produced, the epiglottis leaves the 'at rest' position and moves towards the back wall of the pharynx, until it comes very close to it. This rearward movement of the epiglottis is accompanied by a lateral wall constriction at that level, i.e., a sphinteric type of constriction occurs with the epiglottis moving backwards considerably, and the lateral walls moving inwardly, and touching the lateral edges of the epiglottis. This constriction is observed to reach its maximum degree when the word /maʁʁana/ is said by FL where only a short slit remains across in the pharynx. The examples included here show variations in the approximation of the epiglottis to the back wall of the pharynx in the production of these sounds by FL, SA and WL.

/ʁ/ and /ʒ/, as said in isolation, are given in Figures 4.14a and b respectively. The constriction in (a) for /ʁ/ is very great and only a narrow gap appears. The upper edge of the epiglottis is uncurled. In b, the gap for the pharyngeal /ʒ/ in isolation appears a little wider than it is for /ʁ/, and the upper edge of the epiglottis is not uncurled as much. When /ʁ/ occurs in an initial position



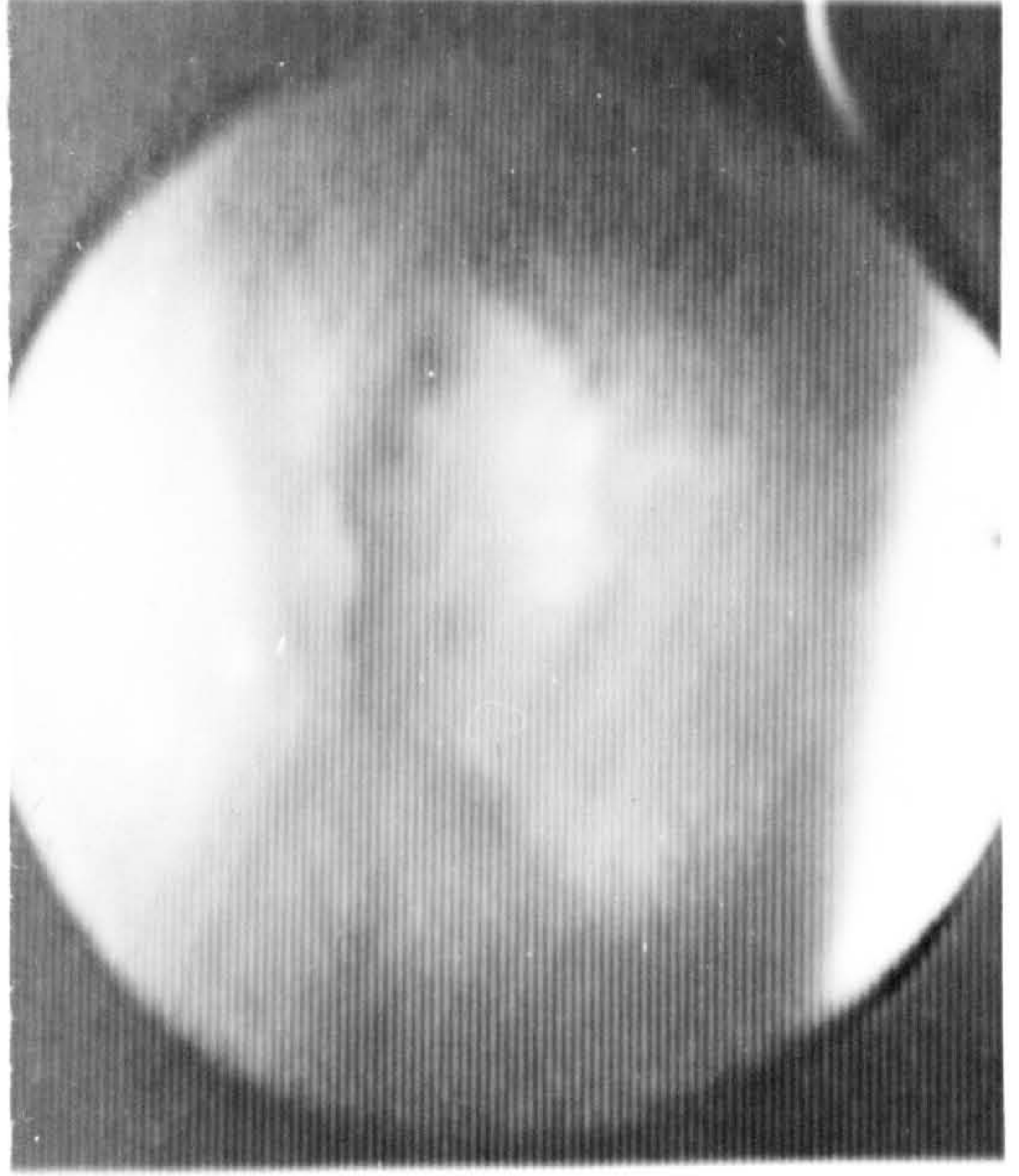
a. /X/ (FL)



b. /3/ (FL)

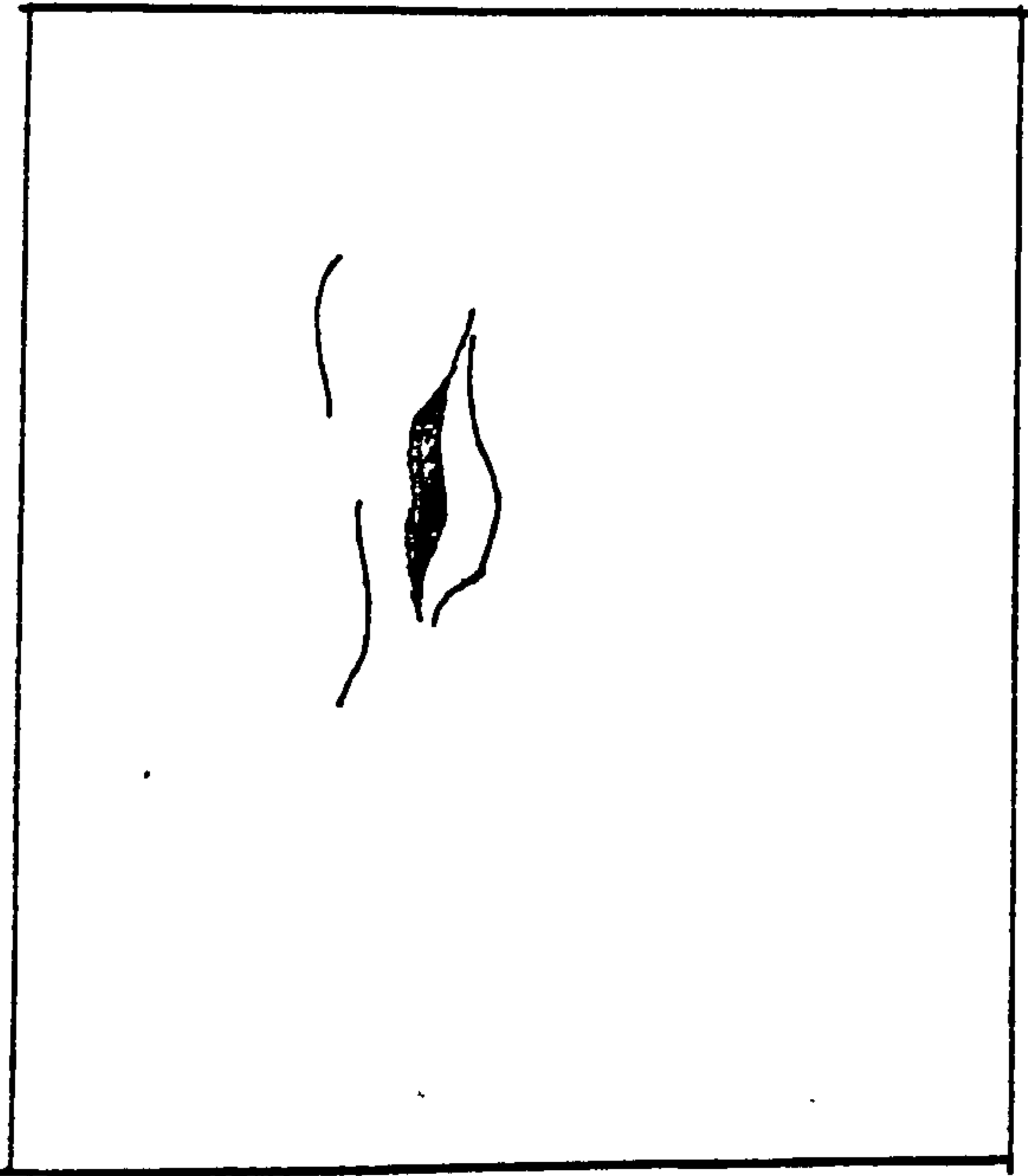


c. /X/ in /Xilim/ (FL)

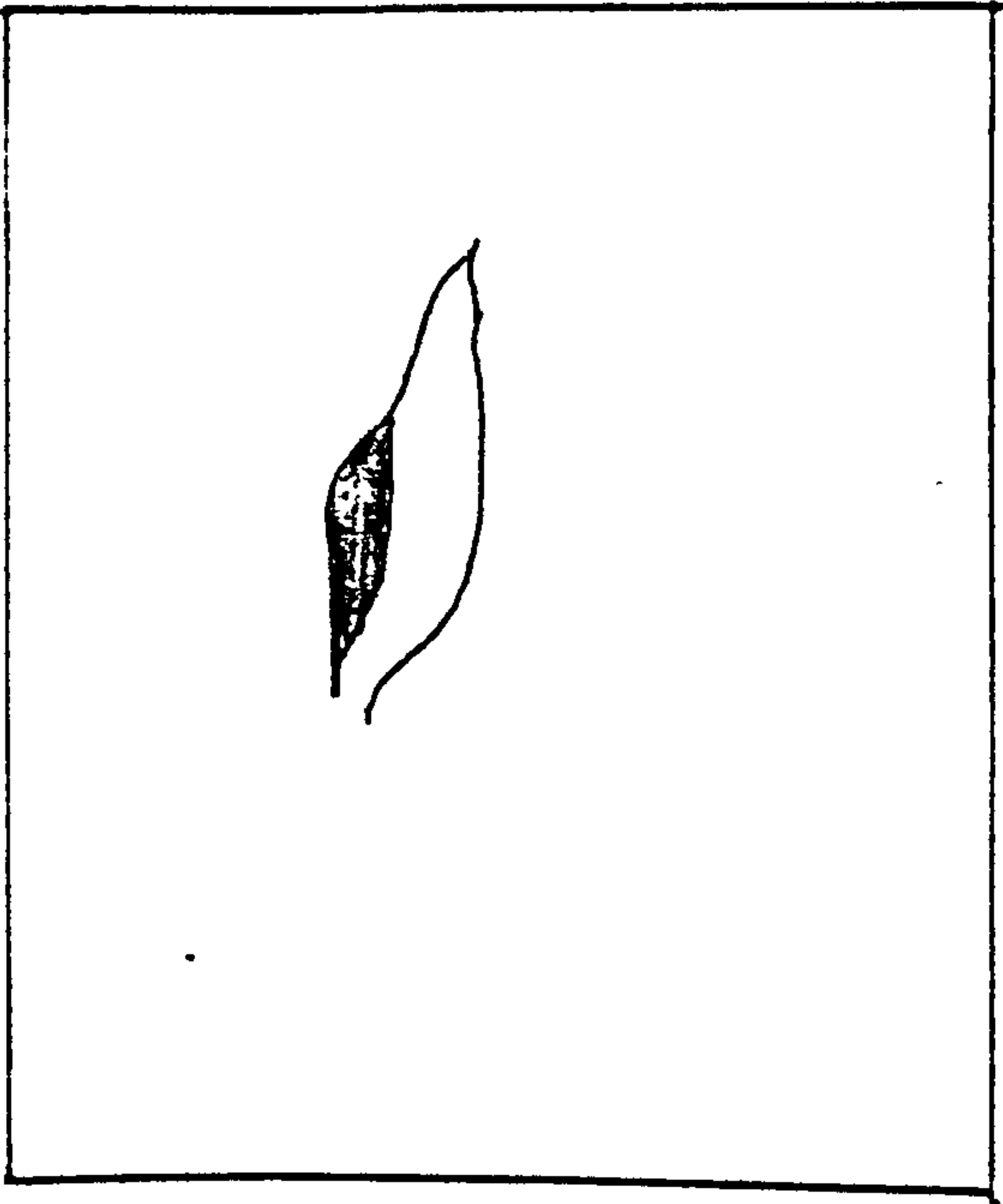


d. /i/ in /Xilim/ (FL)

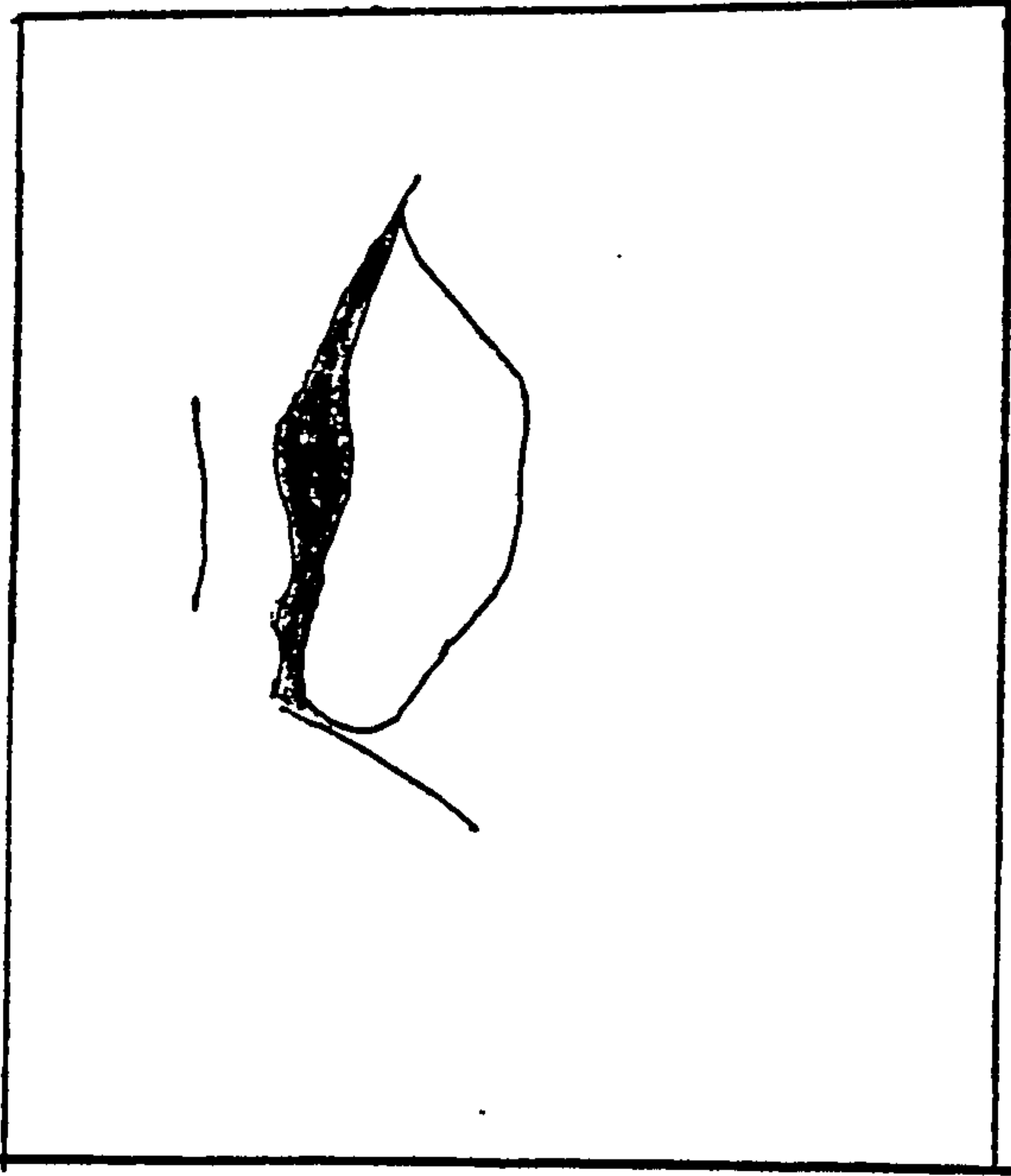
a.



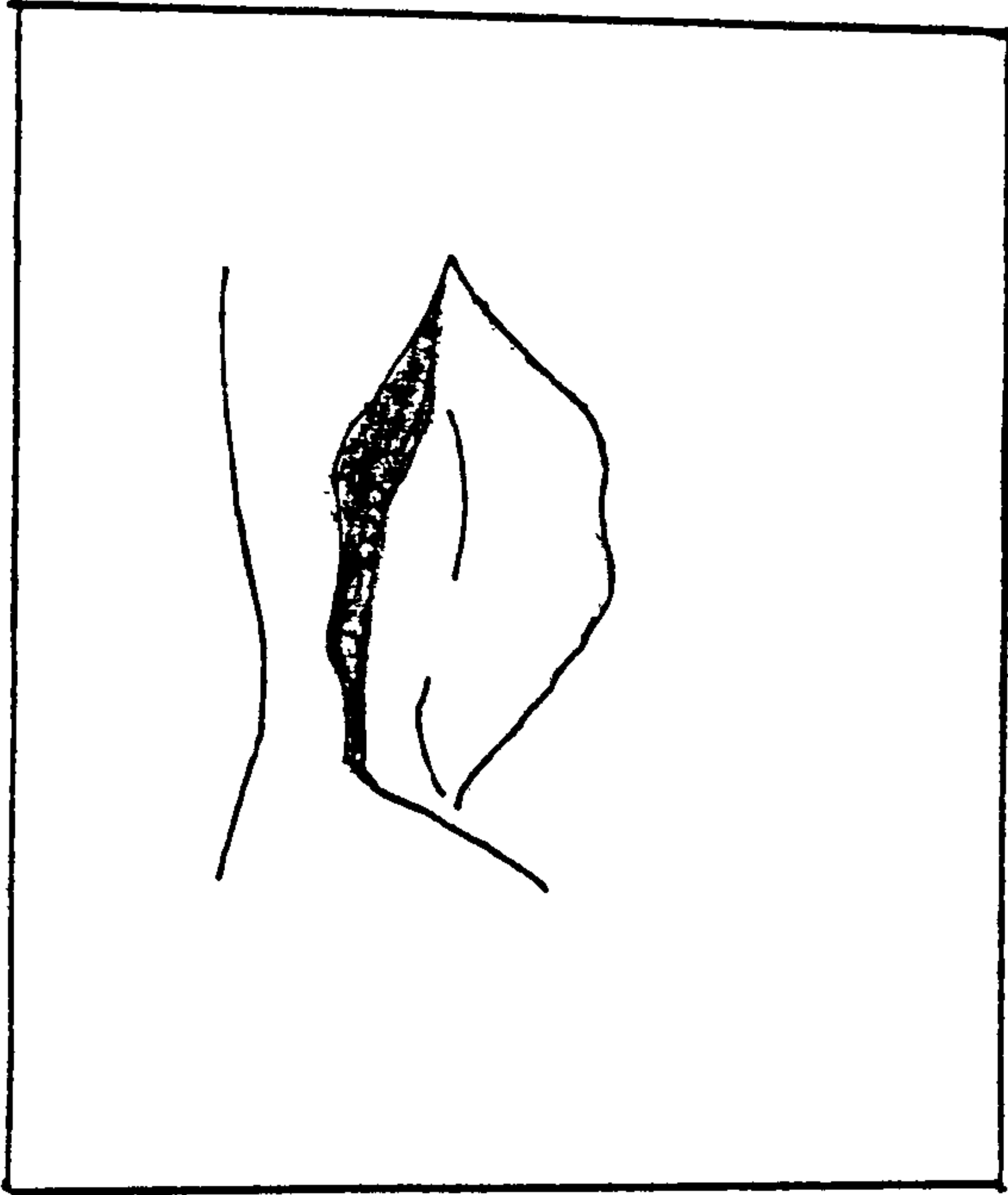
b.



c.



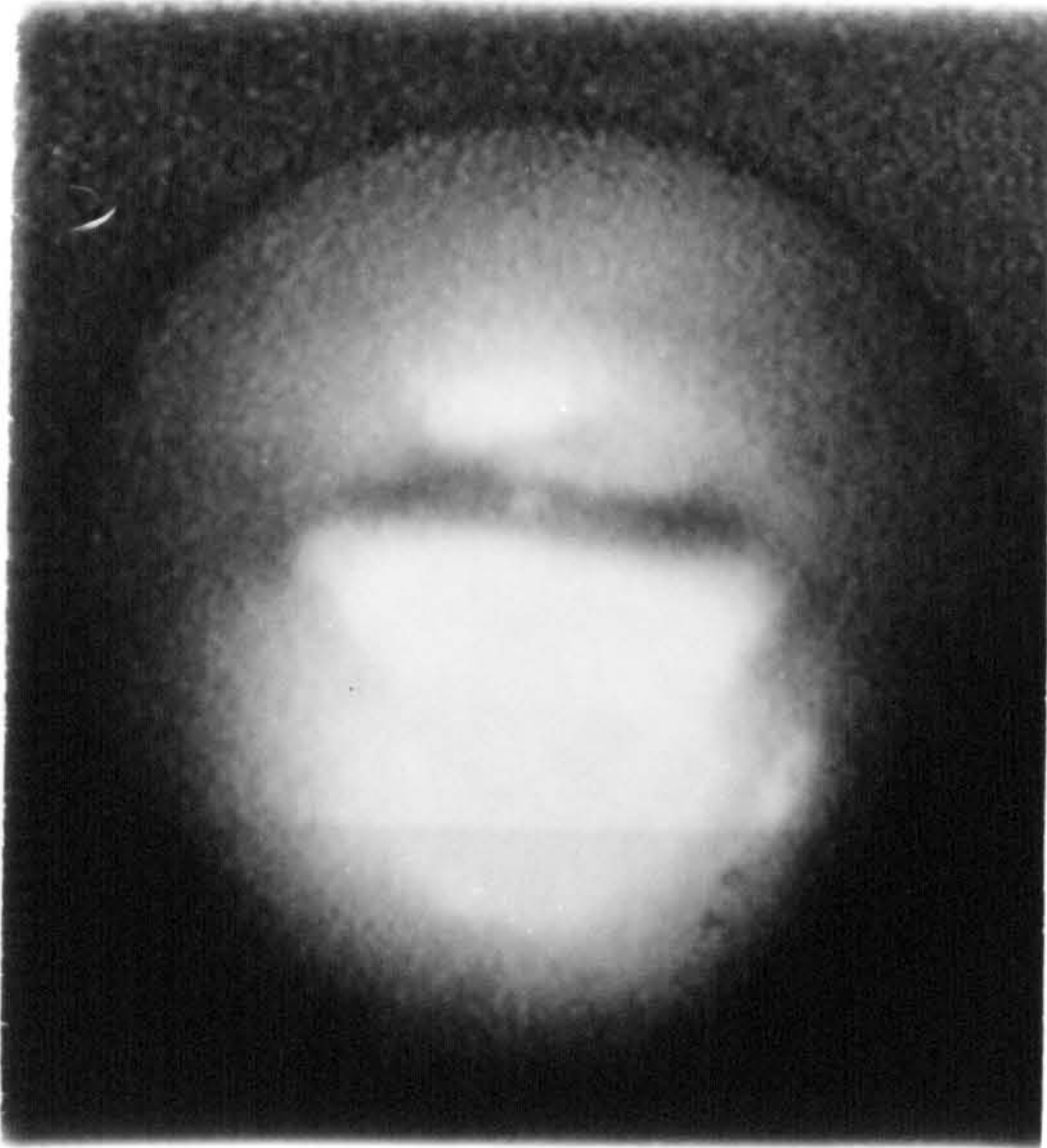
d.



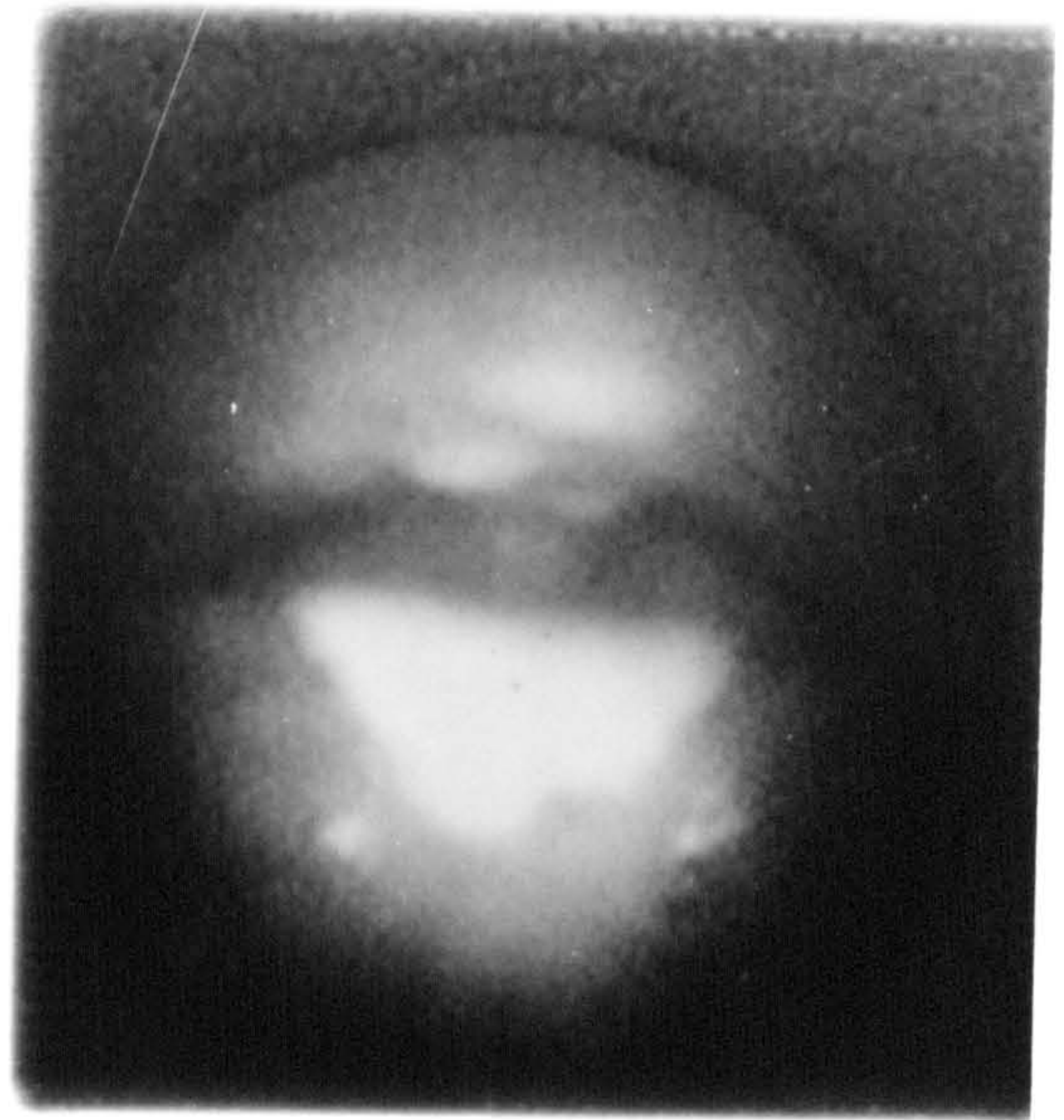
Sketches of Figure 4.14

with a front vowel in /Milim/, the examples shown in Figure 4.14.c and d show only a slight variation in the opening between the epiglottis and the back wall of the pharynx, i.e., the epiglottis is still retracted towards the back wall of the pharynx. It also seems that the epiglottis or the part nearest the back wall is being pulled downwards, while the upper part that one sees is being straightened and pulled upwards and forwards for the articulation of the vowel /i/.

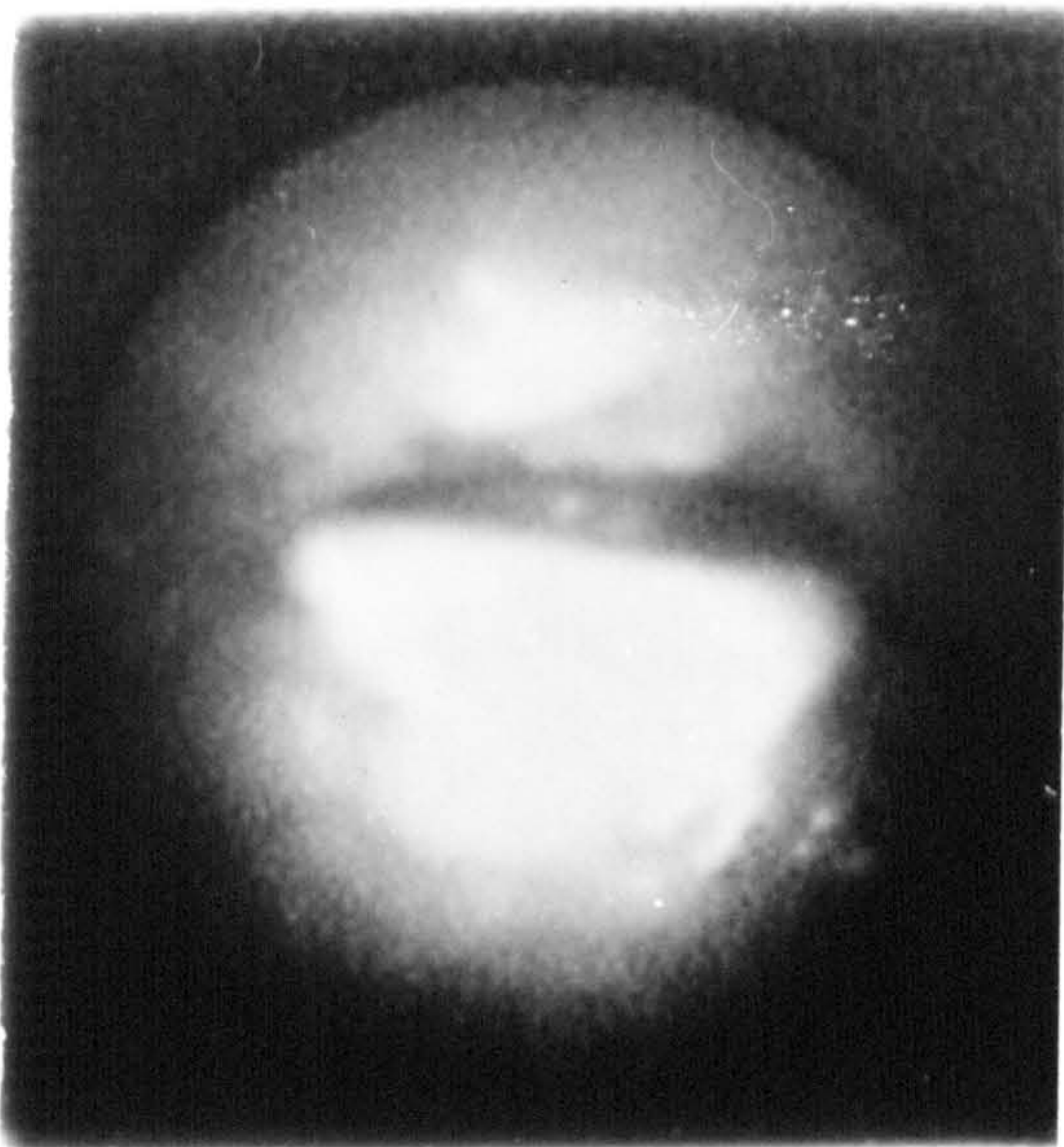
In /3alam/, Figure 4.15.a, as said by WL, the gap between epiglottis and back wall of the pharynx is broader (length from side to side) than in the case of the examples of FL, and it is broader still in the case of SA. These appear to be physiological variations as well as variations resulting from the distance between the anatomical structures and the distal end of the endoscope which seems to be greater in the case of FL. This again emphasises the inadequacy of this method to relate the position of the distal end to the wall of the pharynx to ensure the same constant distance. In the example of /3alam/, the epiglottis is not uncurled. In /3add/, Figure 4.16.d, as said by SA, the constriction is wider than that in /3alam/ of WL. The upper edge of the epiglottis is the same shape as that for the 'at rest' position. In the example of /?alam/, Figure 4.15.b, the opening between the epiglottis and the back wall of the pharynx for the initial segment /?/ is larger and no con-



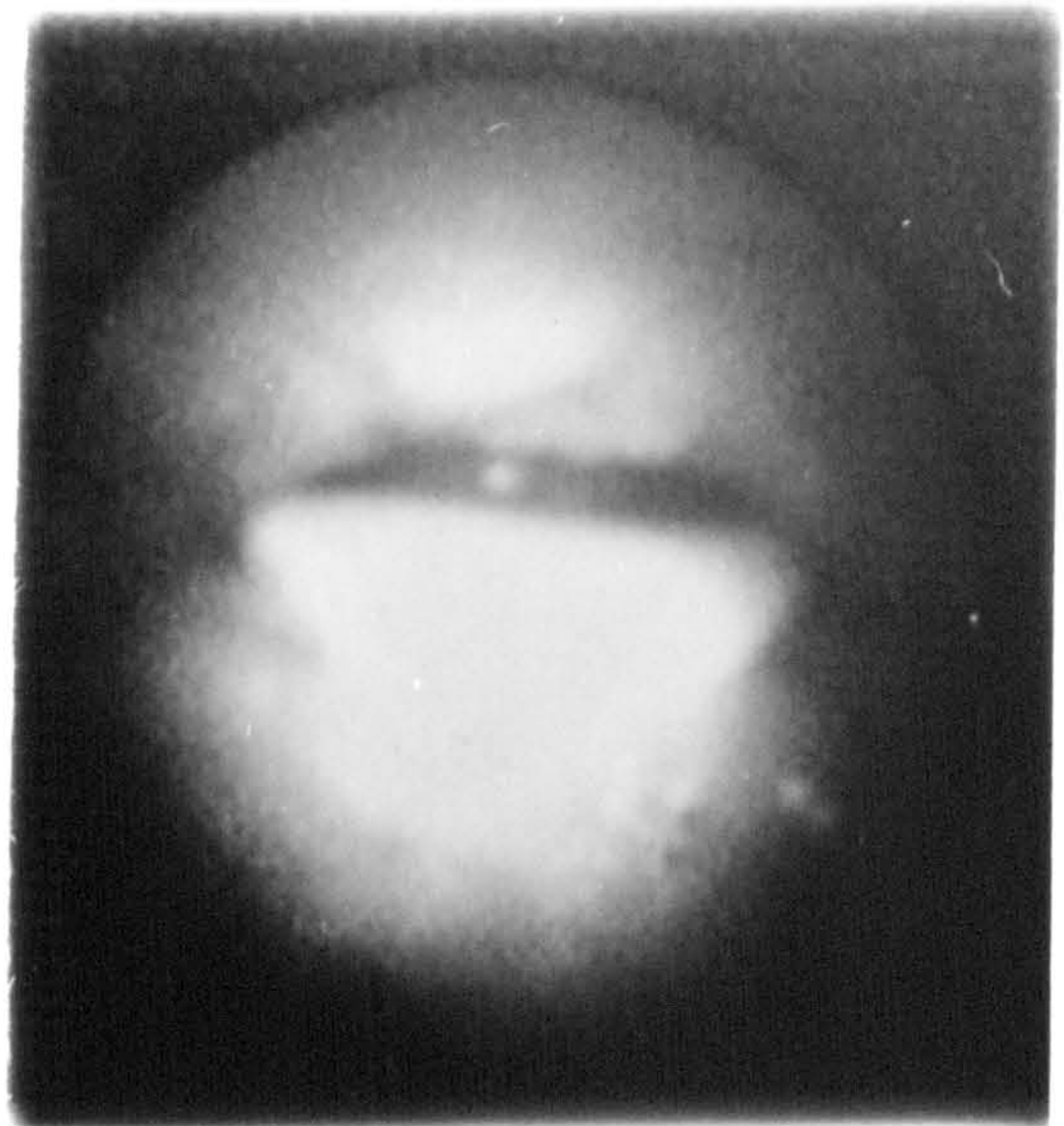
a. /3/ in /3alam/ (WL)



b. /ʔ/ in /ʔalam/ (WL)

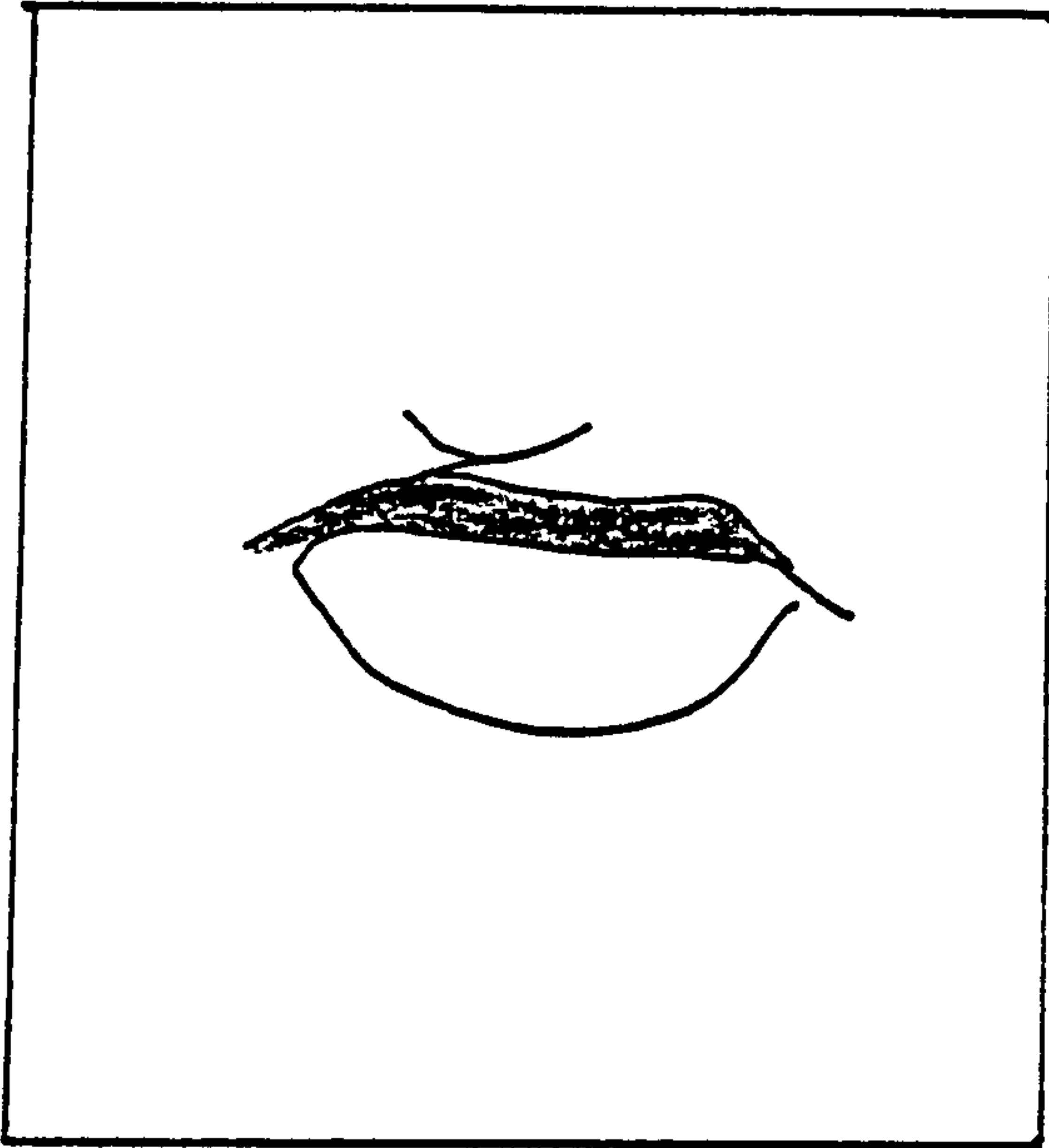


c. /ʎ/ in /sama:ʎ/ (WL)

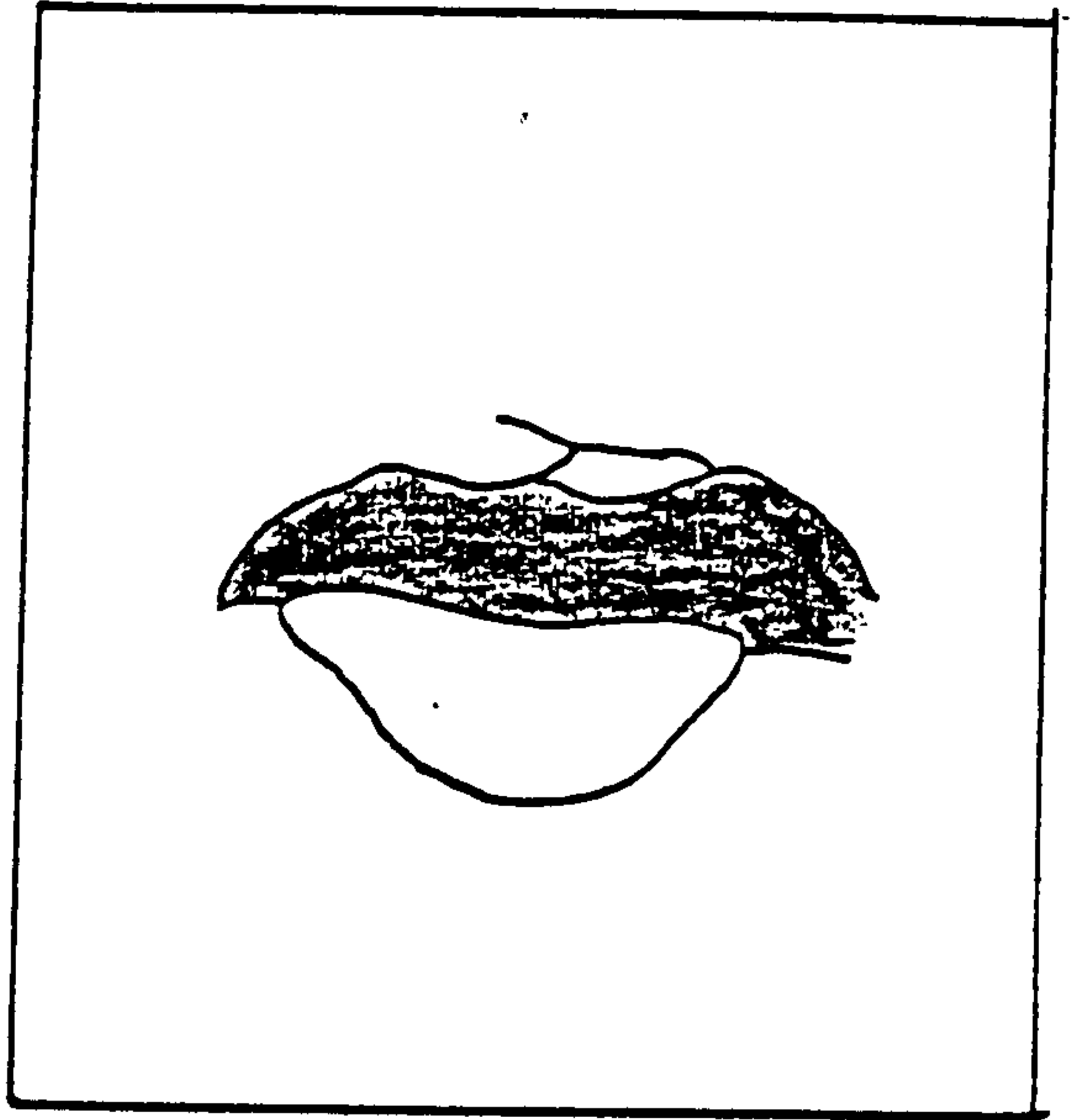


d. /3/ in /sama:3/ (WL)

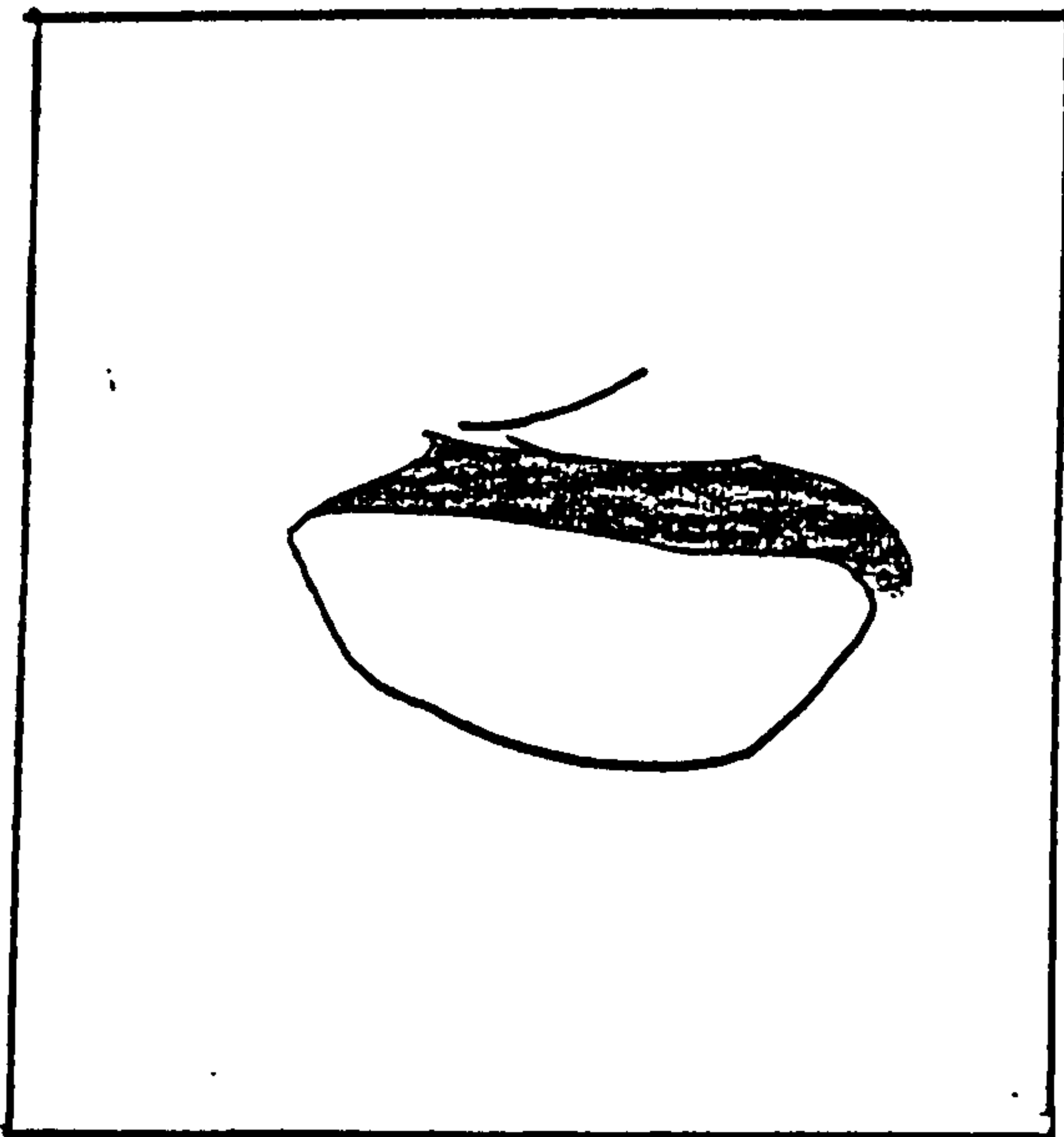
Figure 4.15



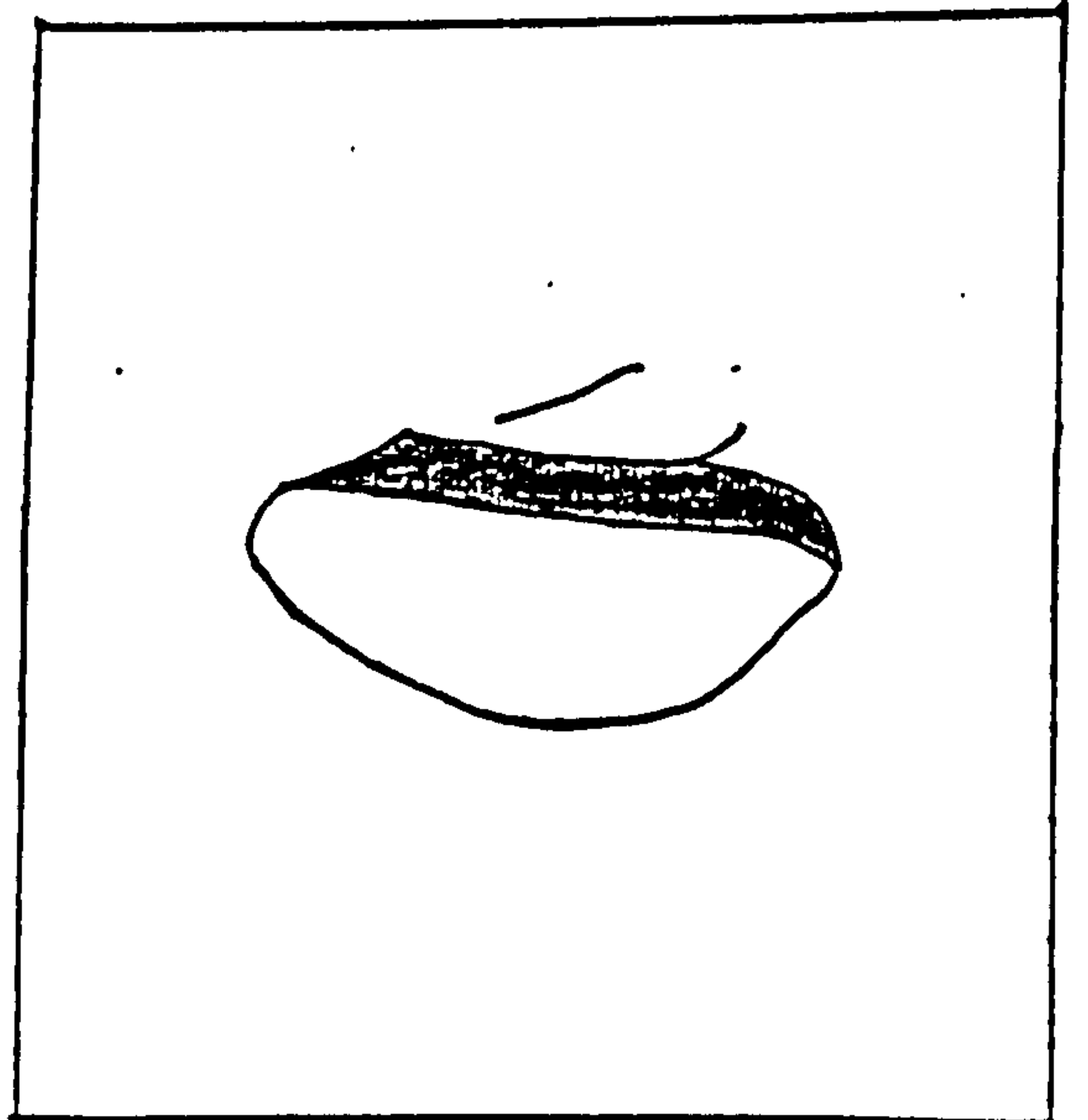
a.



b.

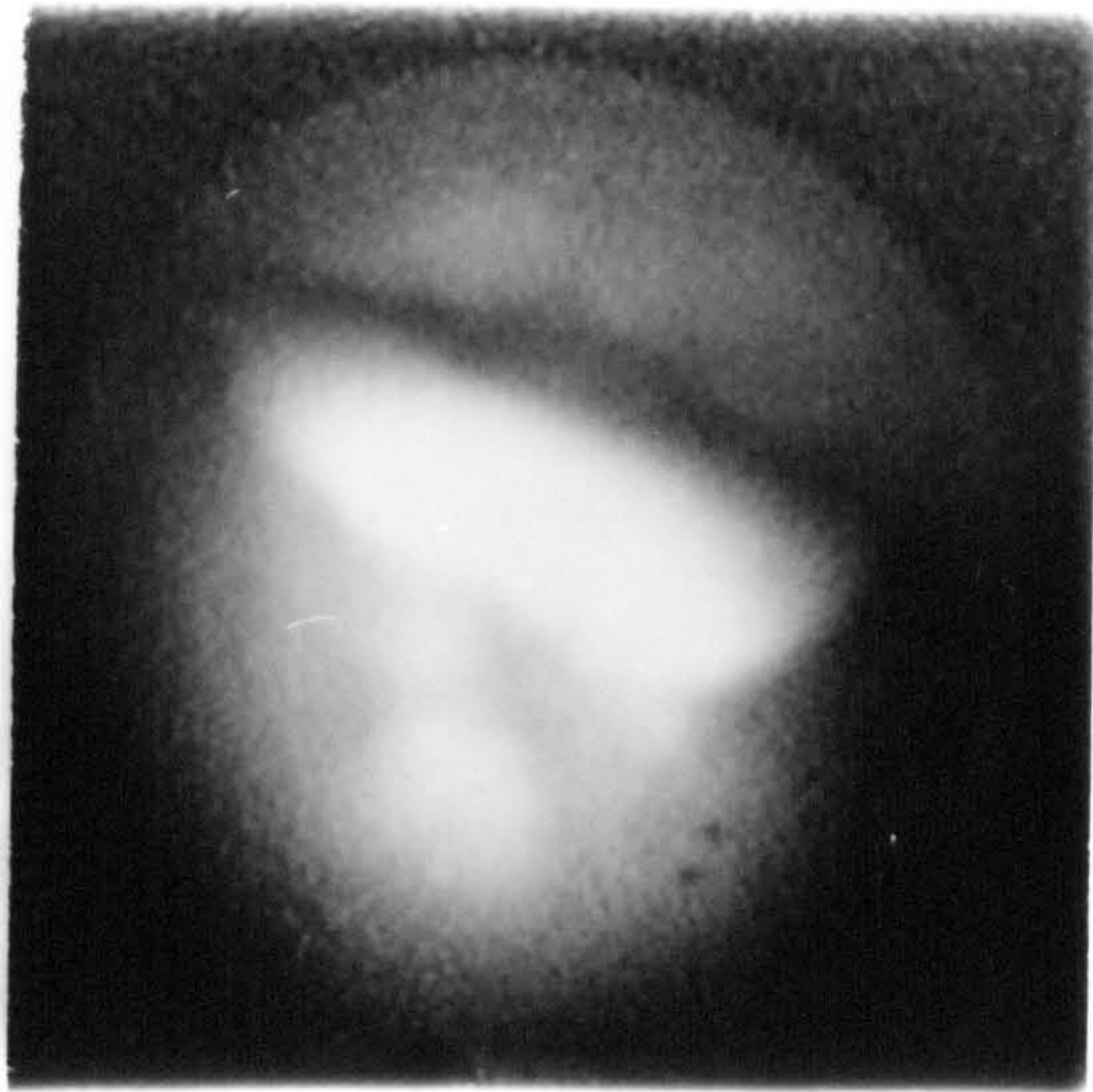


c.

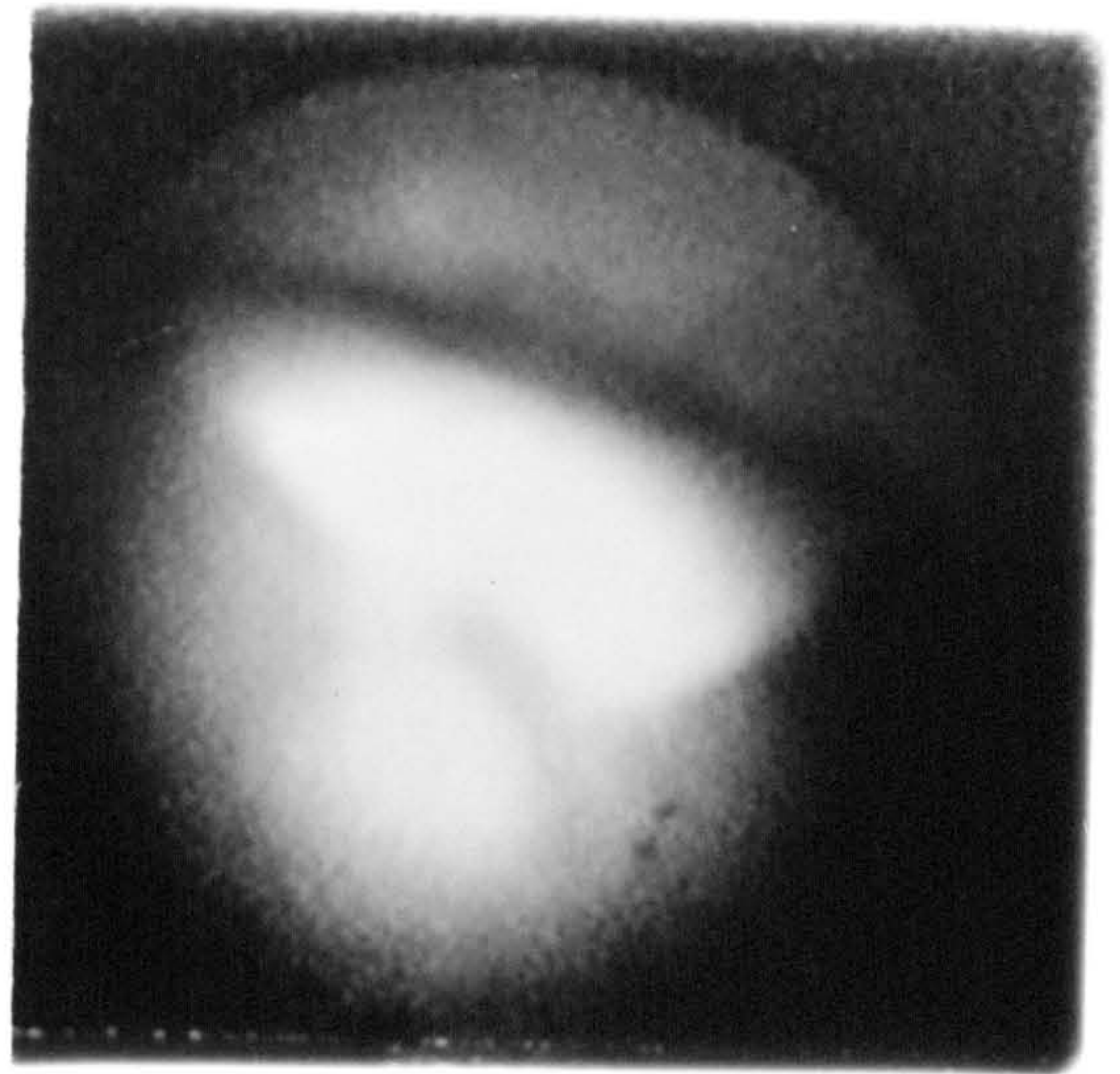


d.

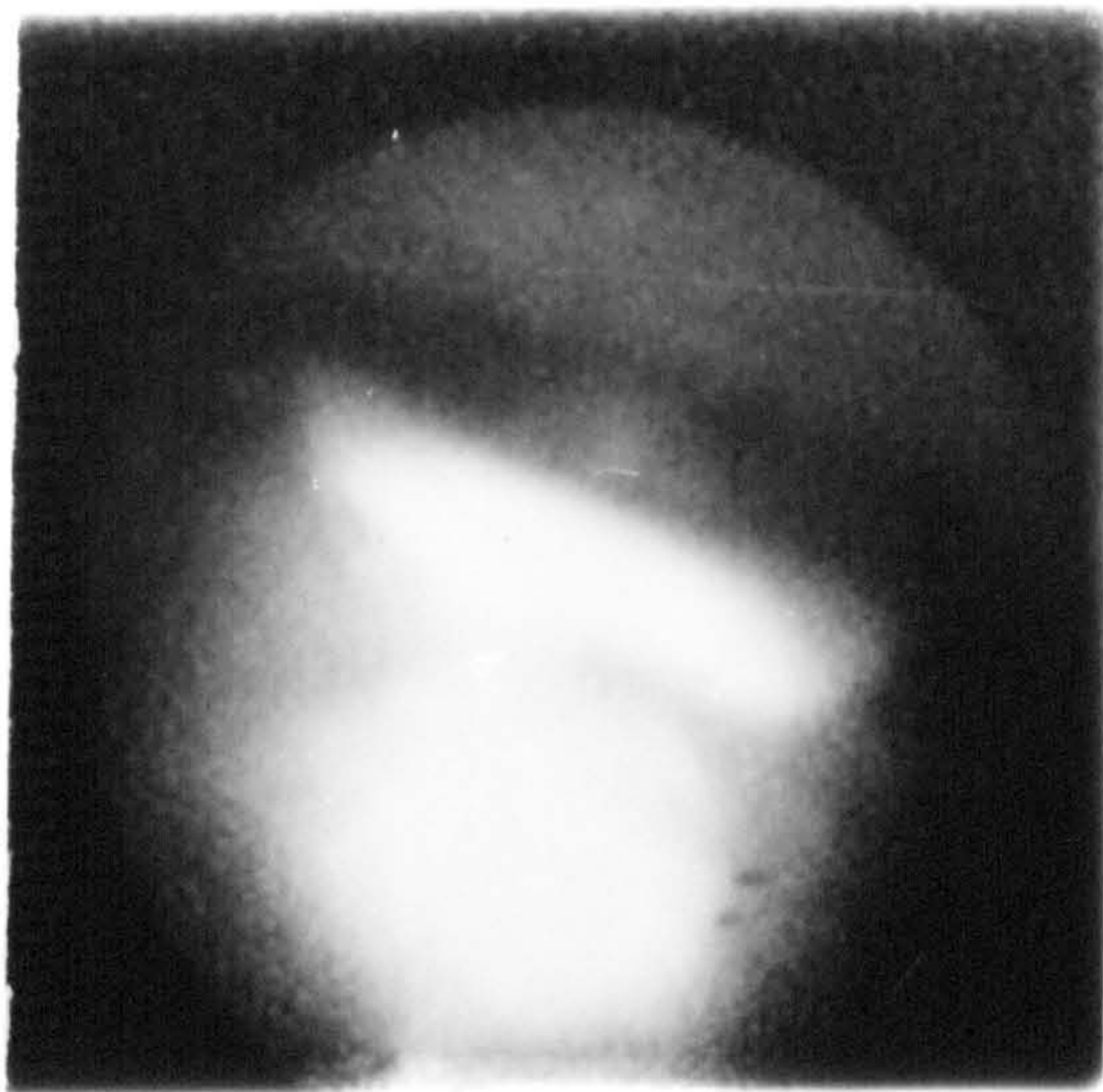
Sketches of Figure 4.15



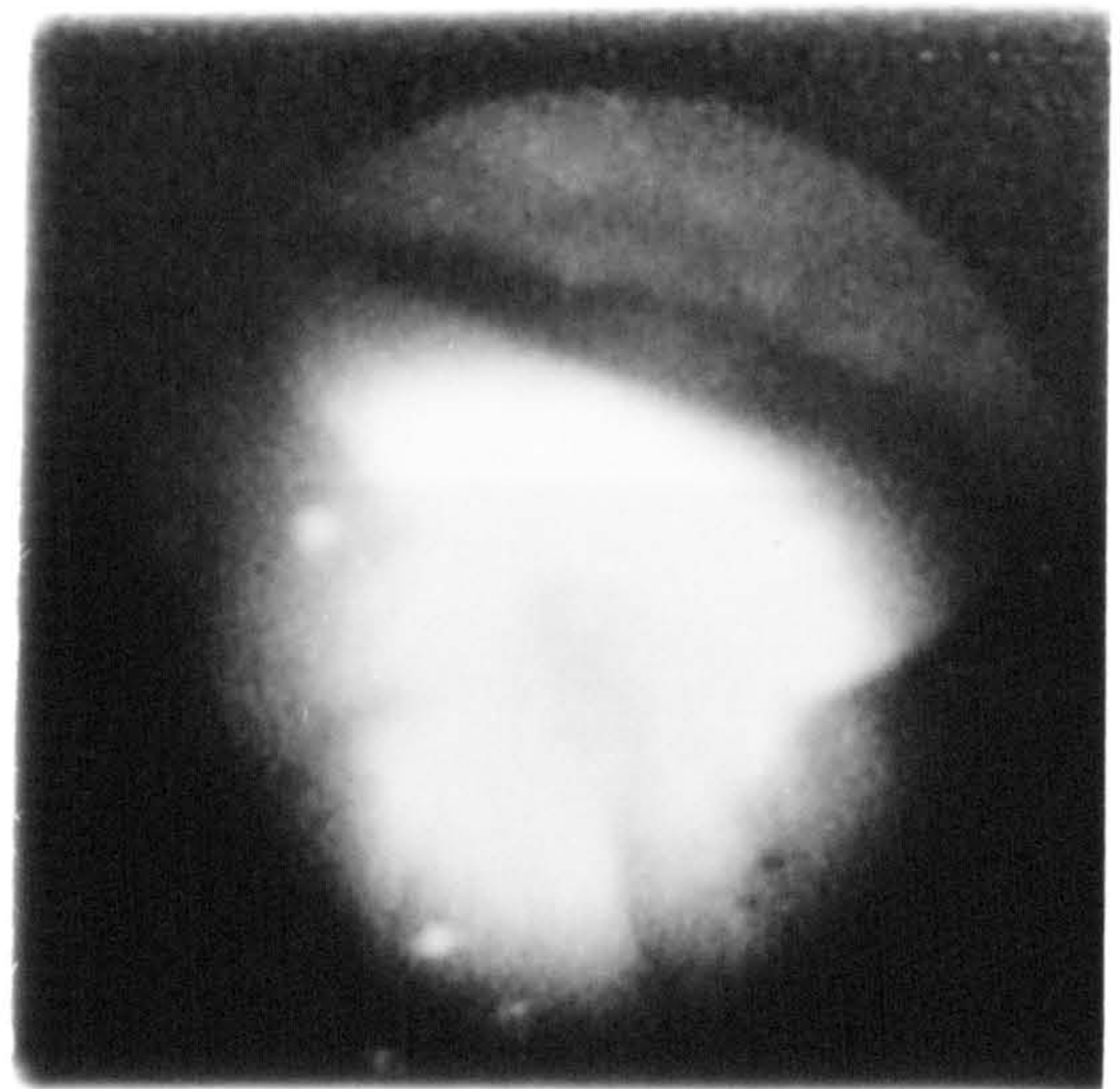
a. /ɛ/ in /raɛa/ (SA)



b. /ɜ/ in /raʒa/ (SA)

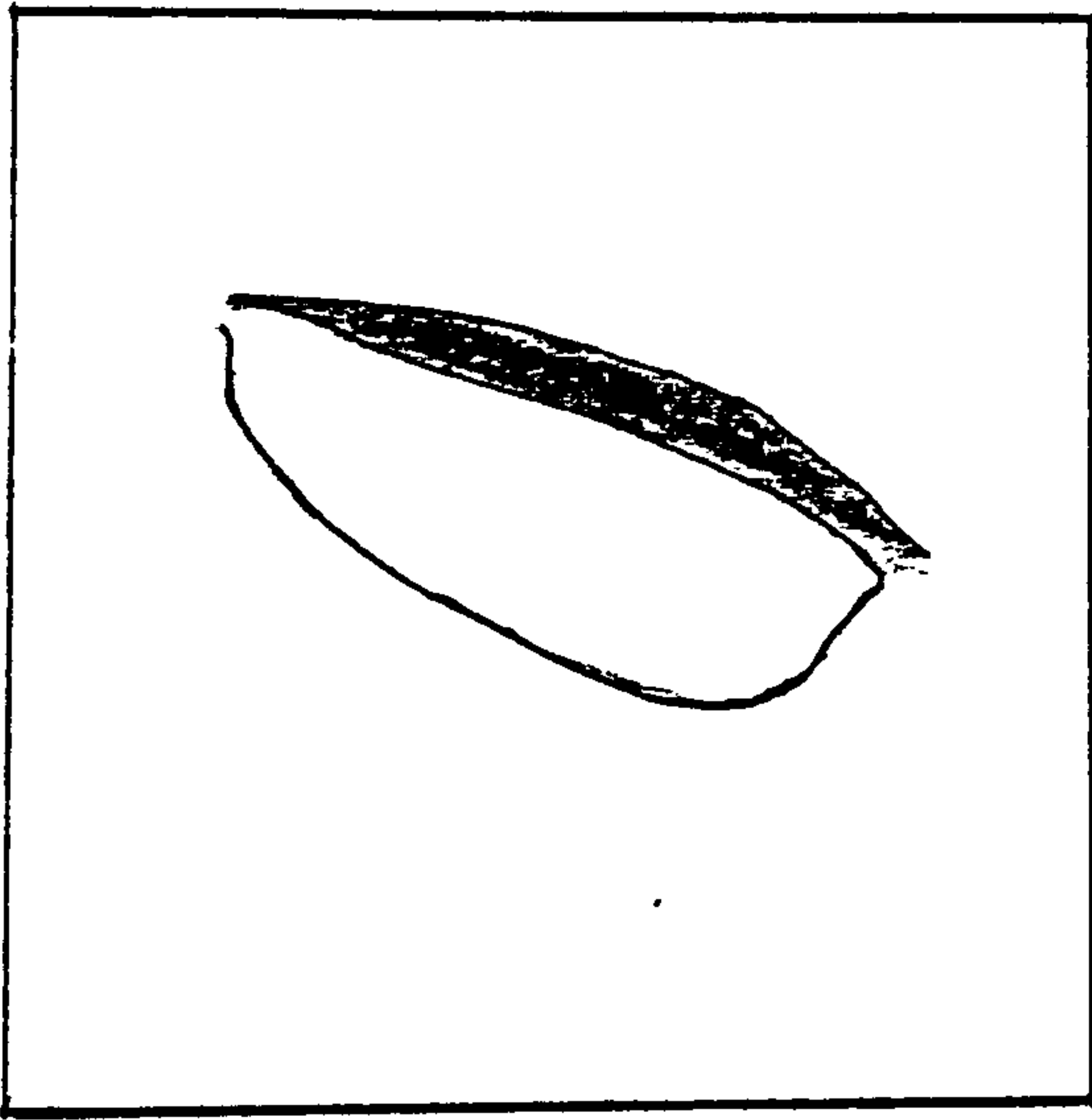


c. /ʔ/ in /raʔa/ (SA)

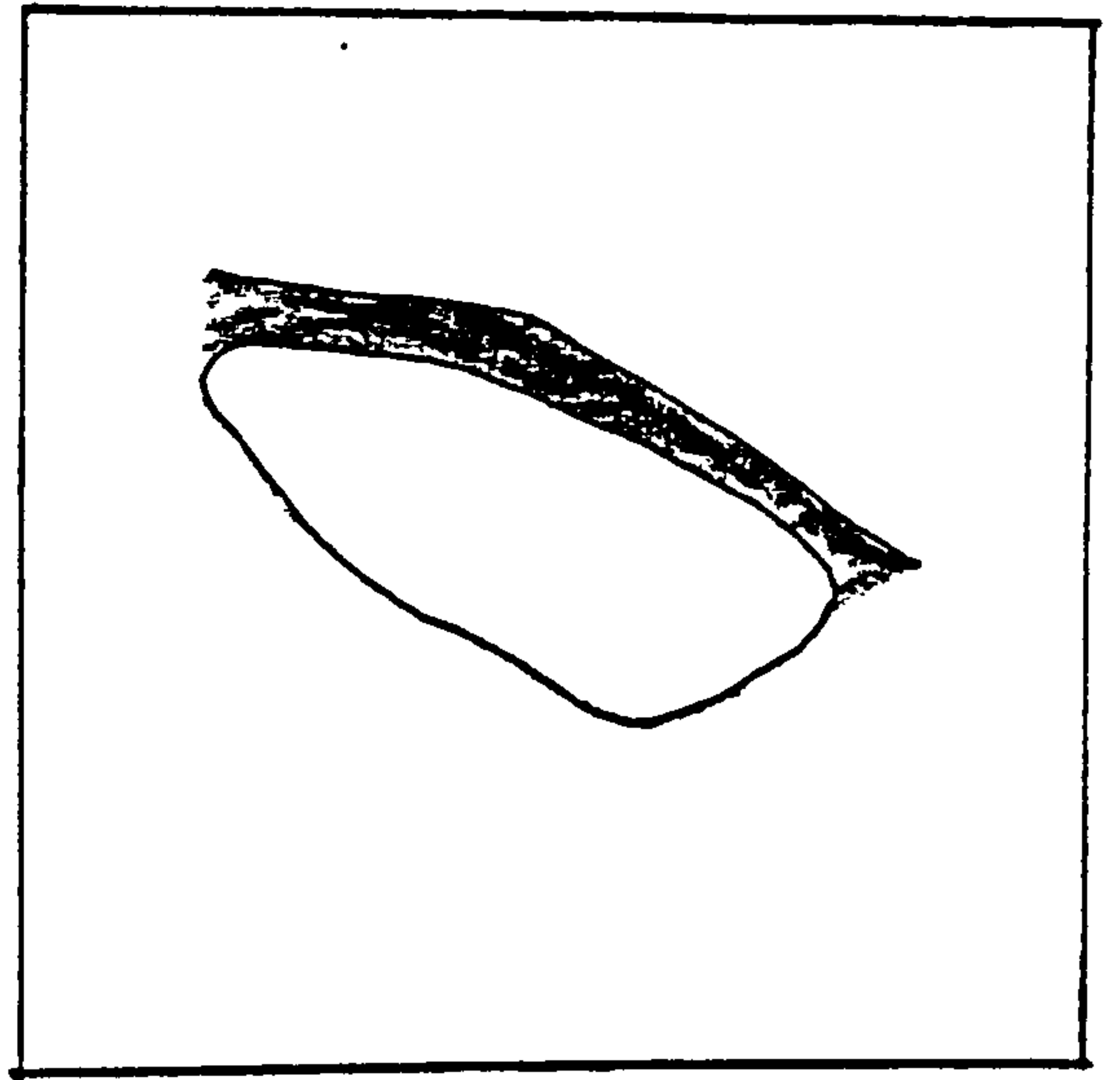


d. /ɜ/ in /ʒadd/ (SA)

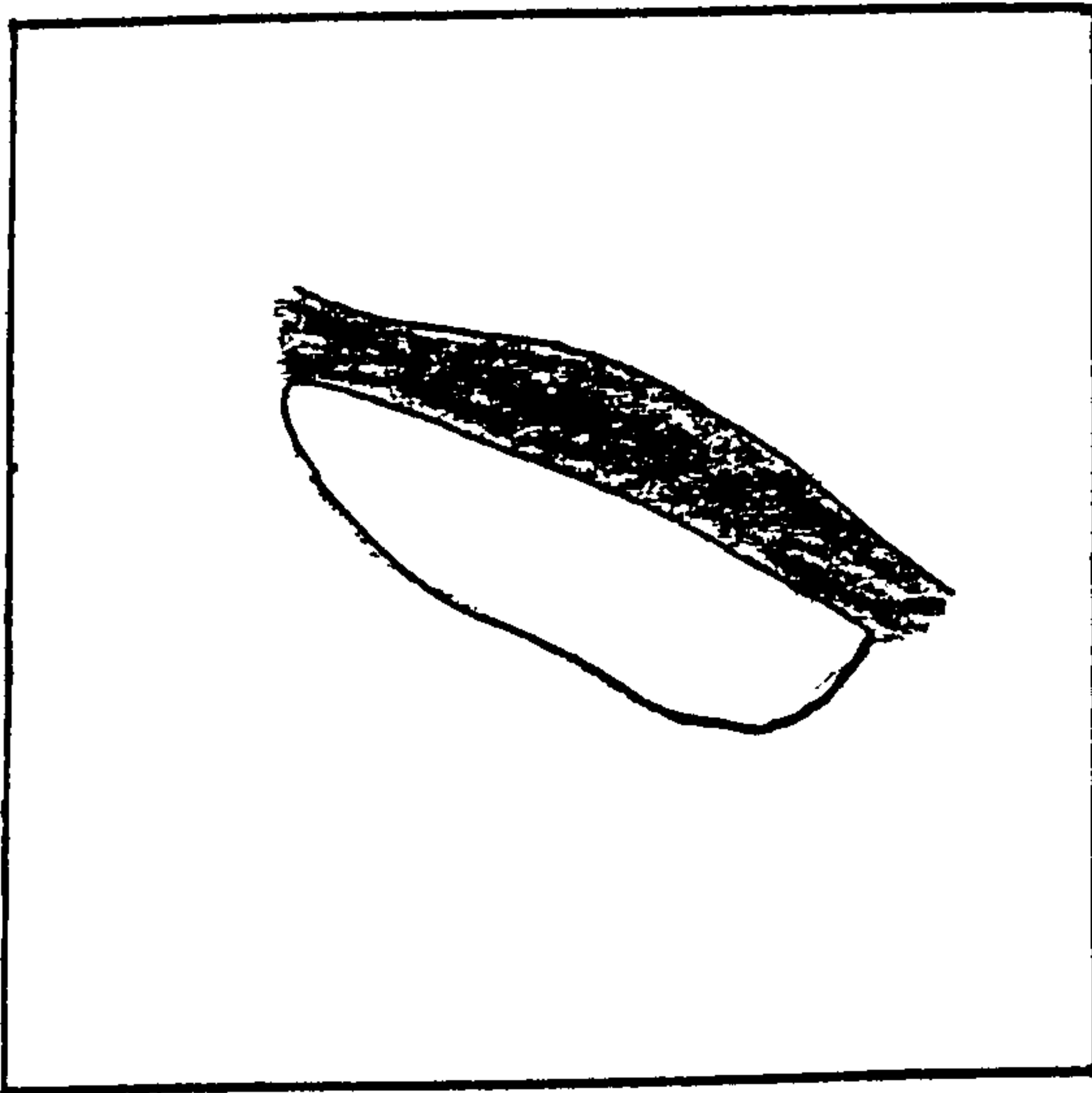
Figure 4.16



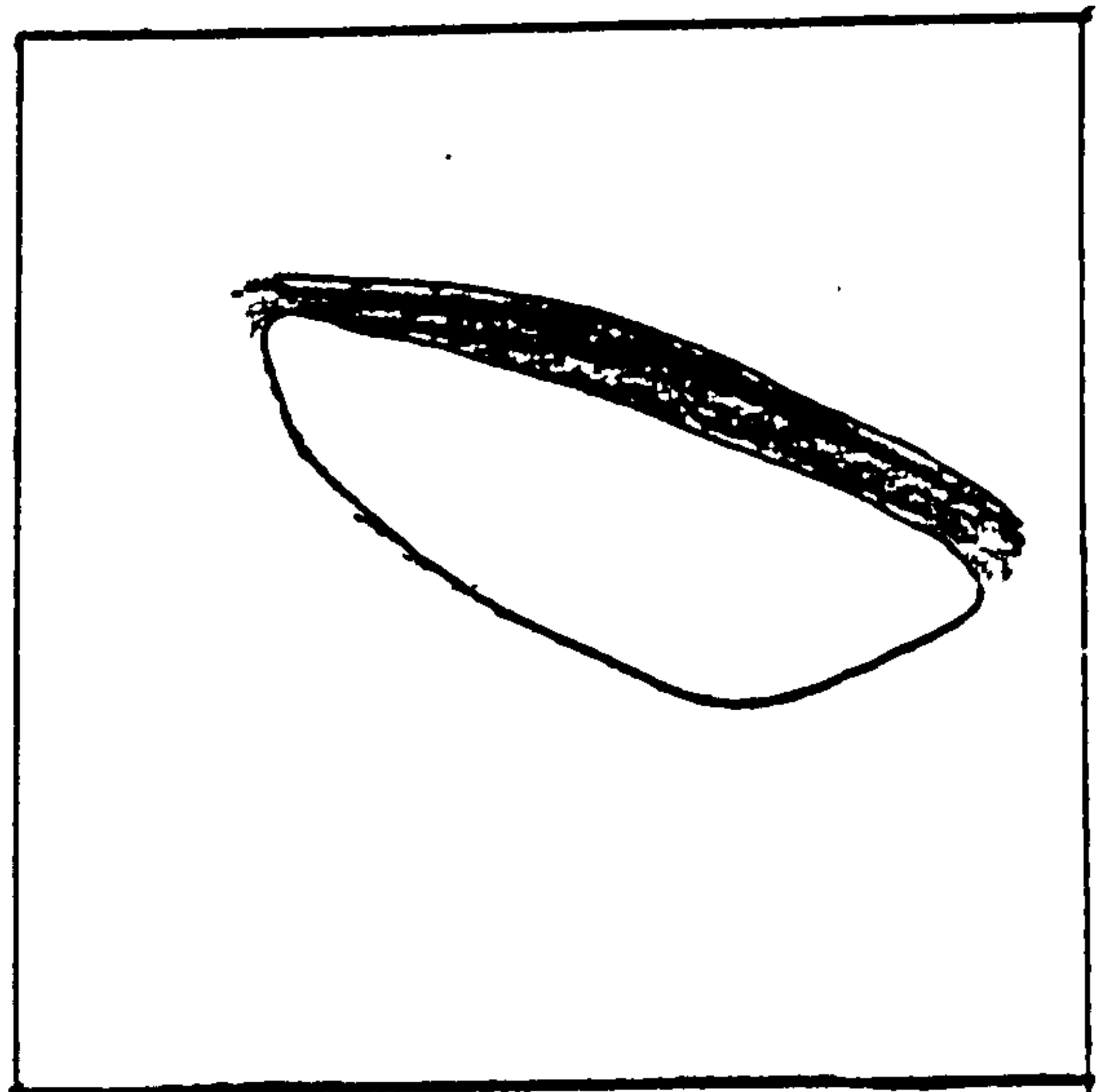
a.



a.



c.



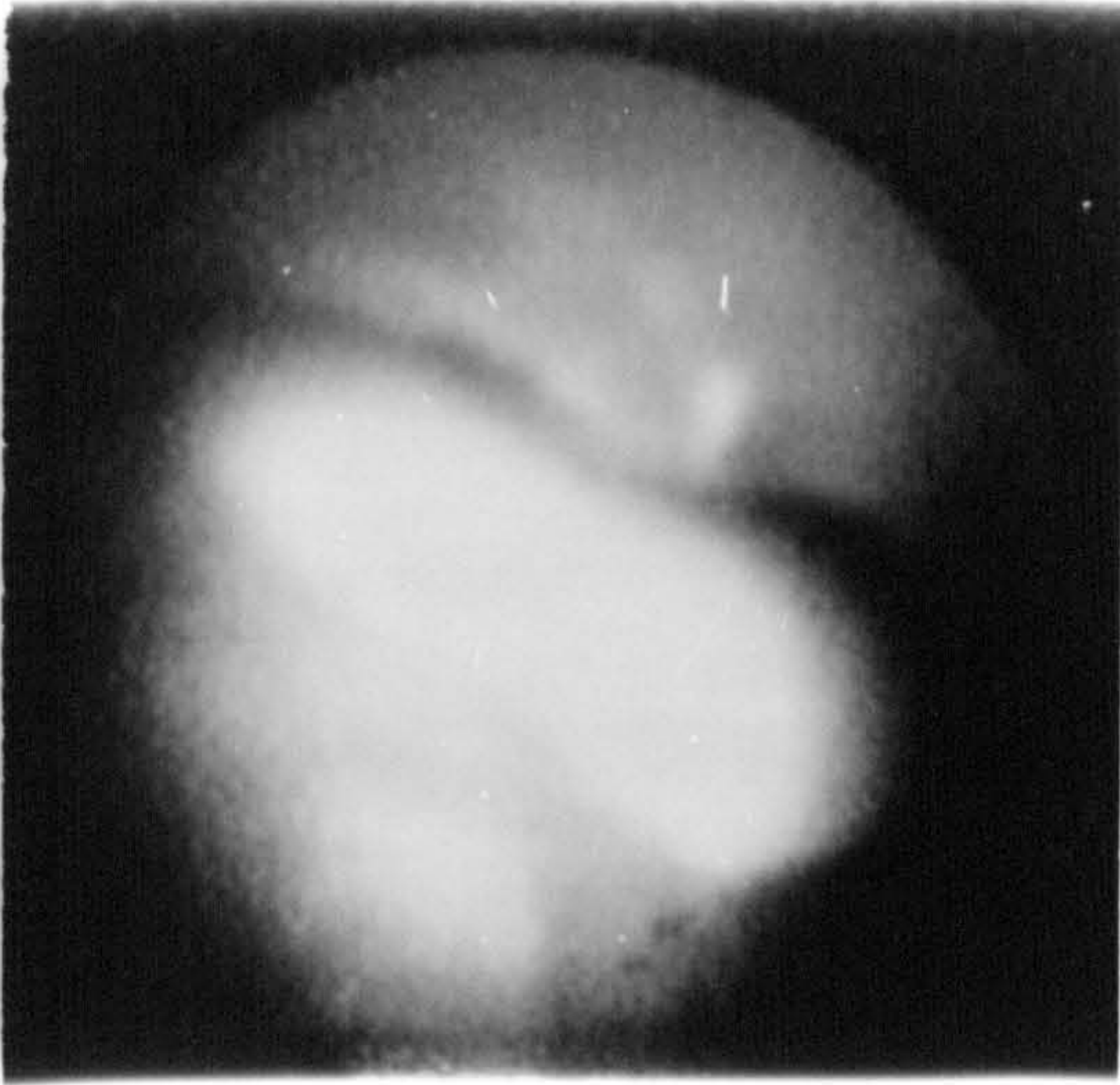
d.

Sketches of Figures 4.16

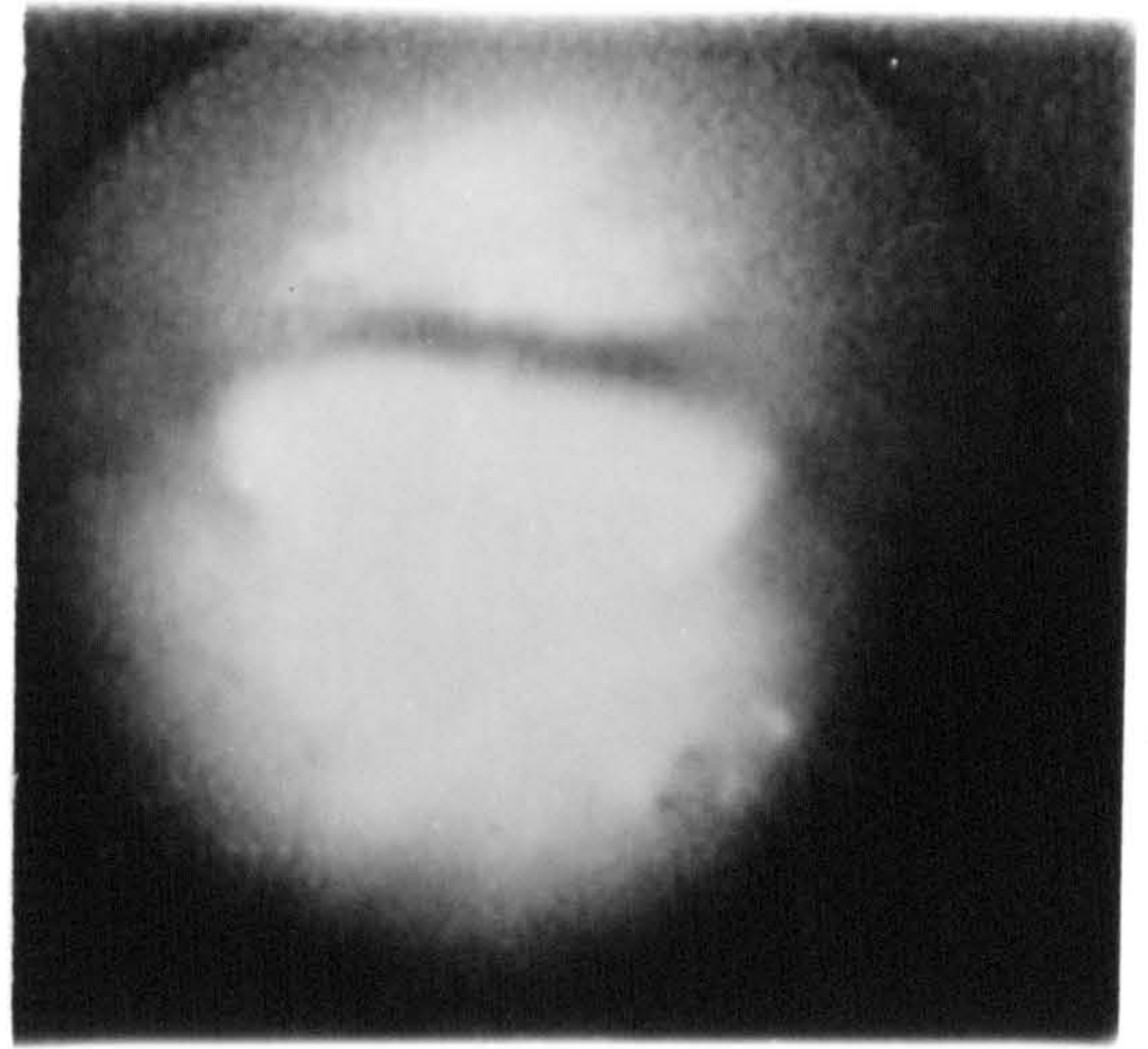
striction in the lateral walls of the pharynx occurs. However, the epiglottis is retracted from the 'at rest' position. The constriction is similar to that of /ʔ/ in /raʔa/, Figure 4.16.c, as said by SA, but the upper edge of the epiglottis is uncurled like that seen for the pharyngealized consonants. This is probably a consequence of the presence of /r/ and the adjacent vowels. This uncurling does not occur, for instance, in /raħa/ and /raʒa/, Figures 4.16.a and b respectively, as said by the same subject. The constriction for these two examples is slightly wider in the middle for /ħ/ than for /ʒ/. This shape of constriction was observed in several examples of /ħ/ by this subject.

The constriction in the pharynx of /ħ/ and /ʒ/ in /sama:ħ/ and /sama:ʒ/, as said by WL, Figures 4.15.c and d respectively, is narrow but not as narrow as that in other examples in other positions. This does not indicate that the occurrence of these sounds in a final position always produces a slightly wider constriction. Though this occurred in one example of /ʒ/ in /sama:ʒ/, as said by FL, the pattern is not really consistent.

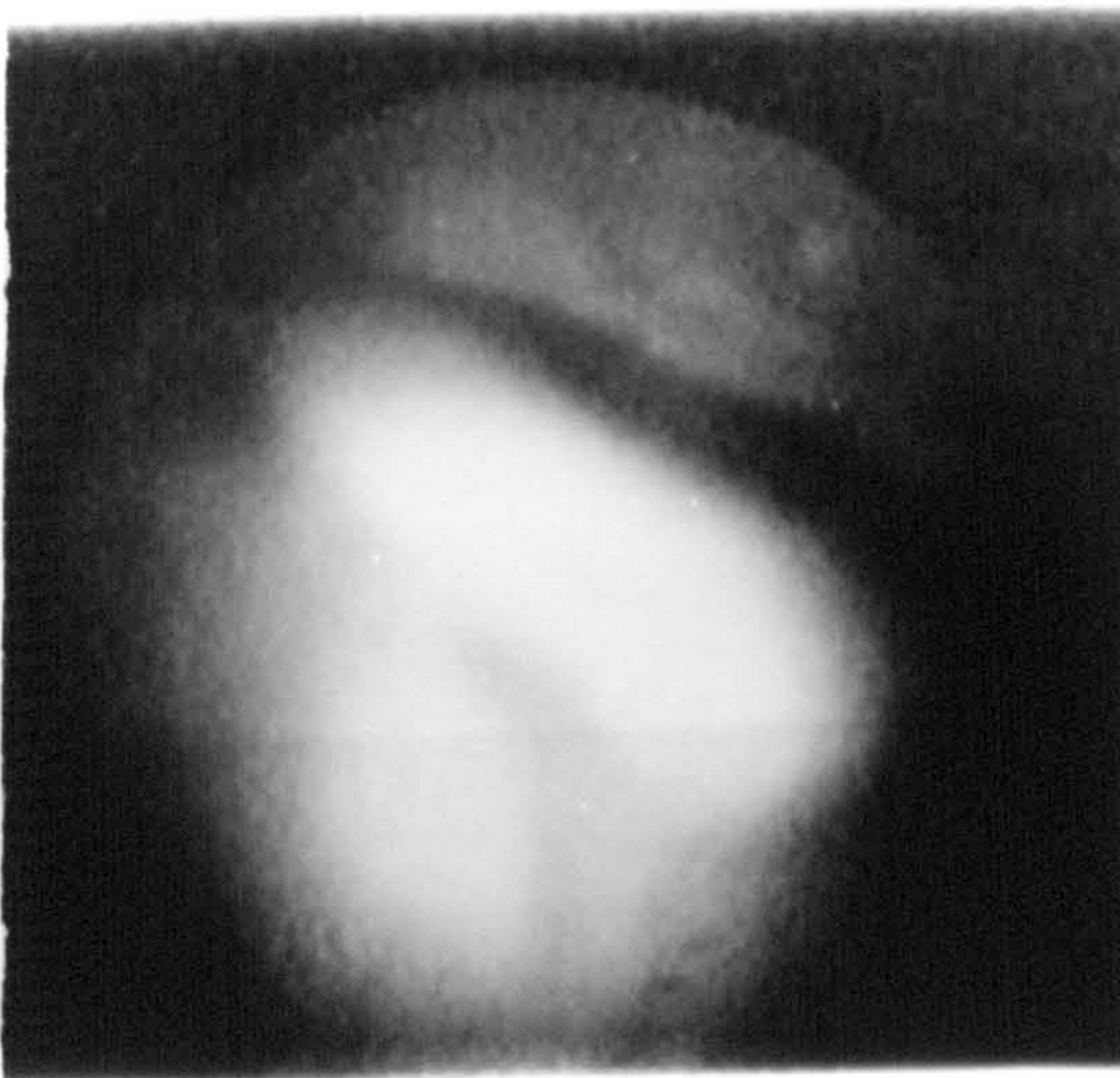
In the examples of /ʒ/ in /waʒd/, as said by SA and WL, Figures 4.17.c. and d respectively, the constriction in the case of /ʒ/, as said by WL, is greater than that of SA and the gap between the epiglottis and the back wall of the



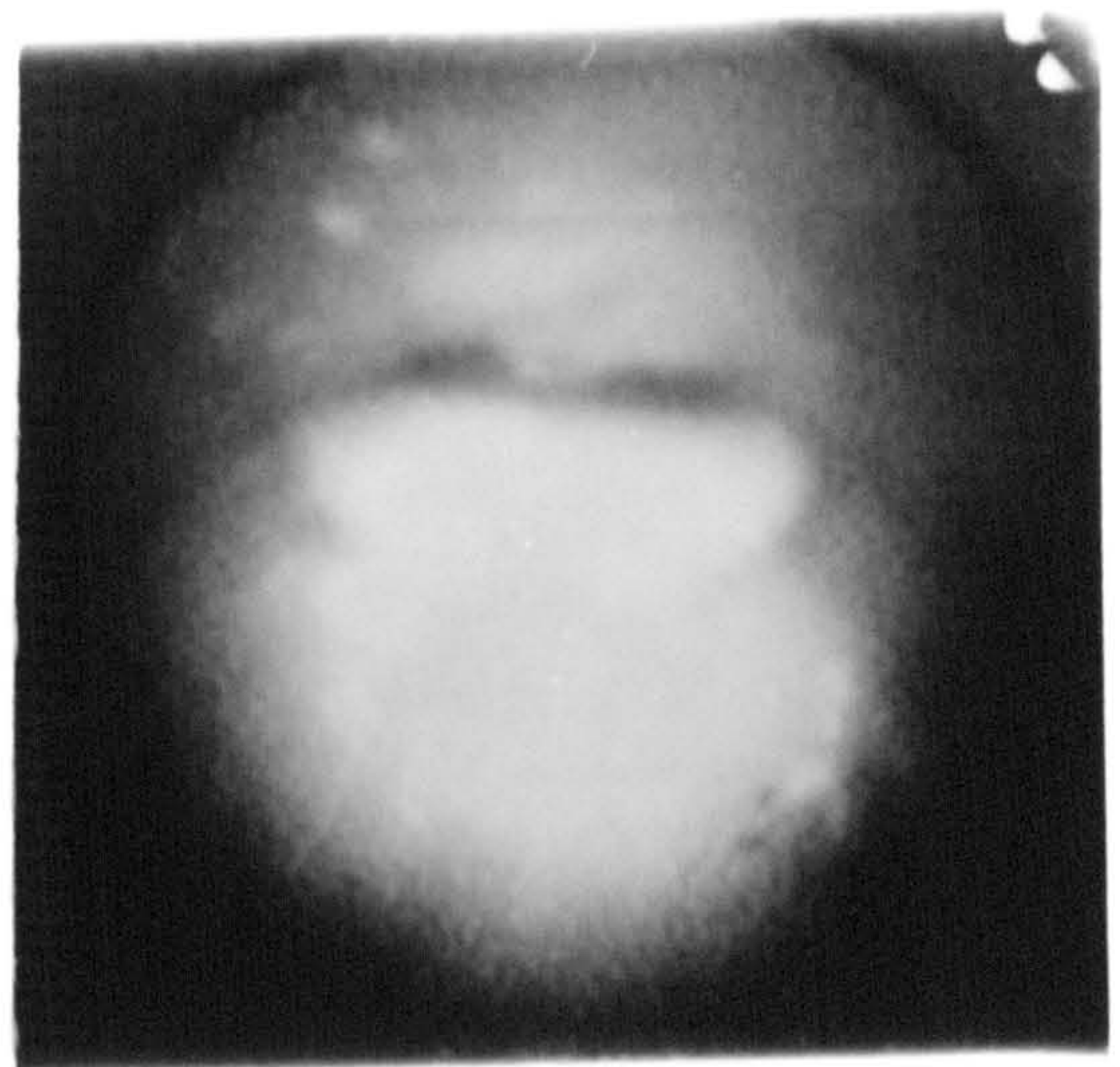
a. /3/ in /sa33ala/ (SA)



b. /3/ in /sa33ala/ (WL)

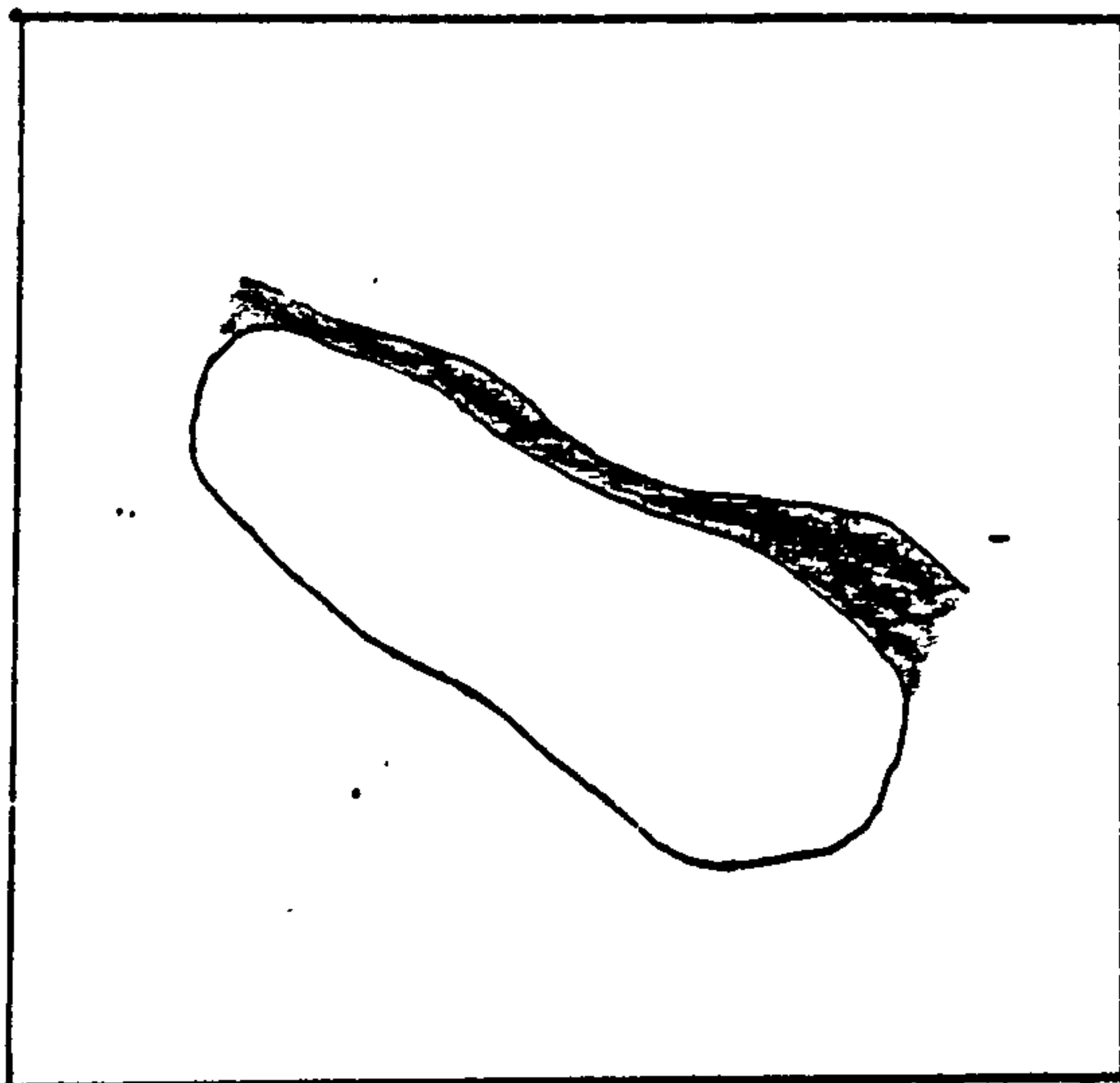


c. /3/ in /wa3d/ (SA)

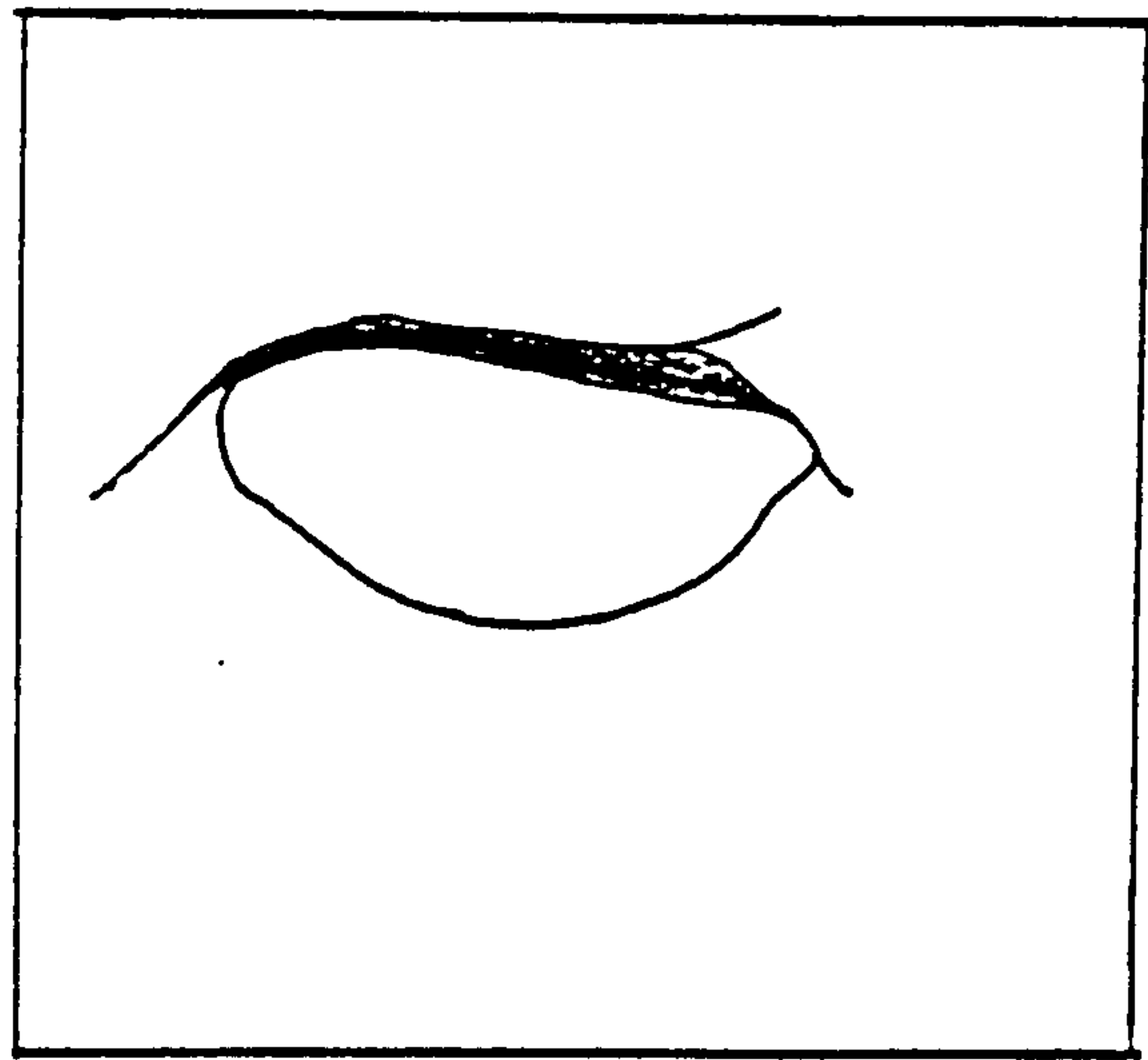


d. /3/ in /wa3d/ (WL)

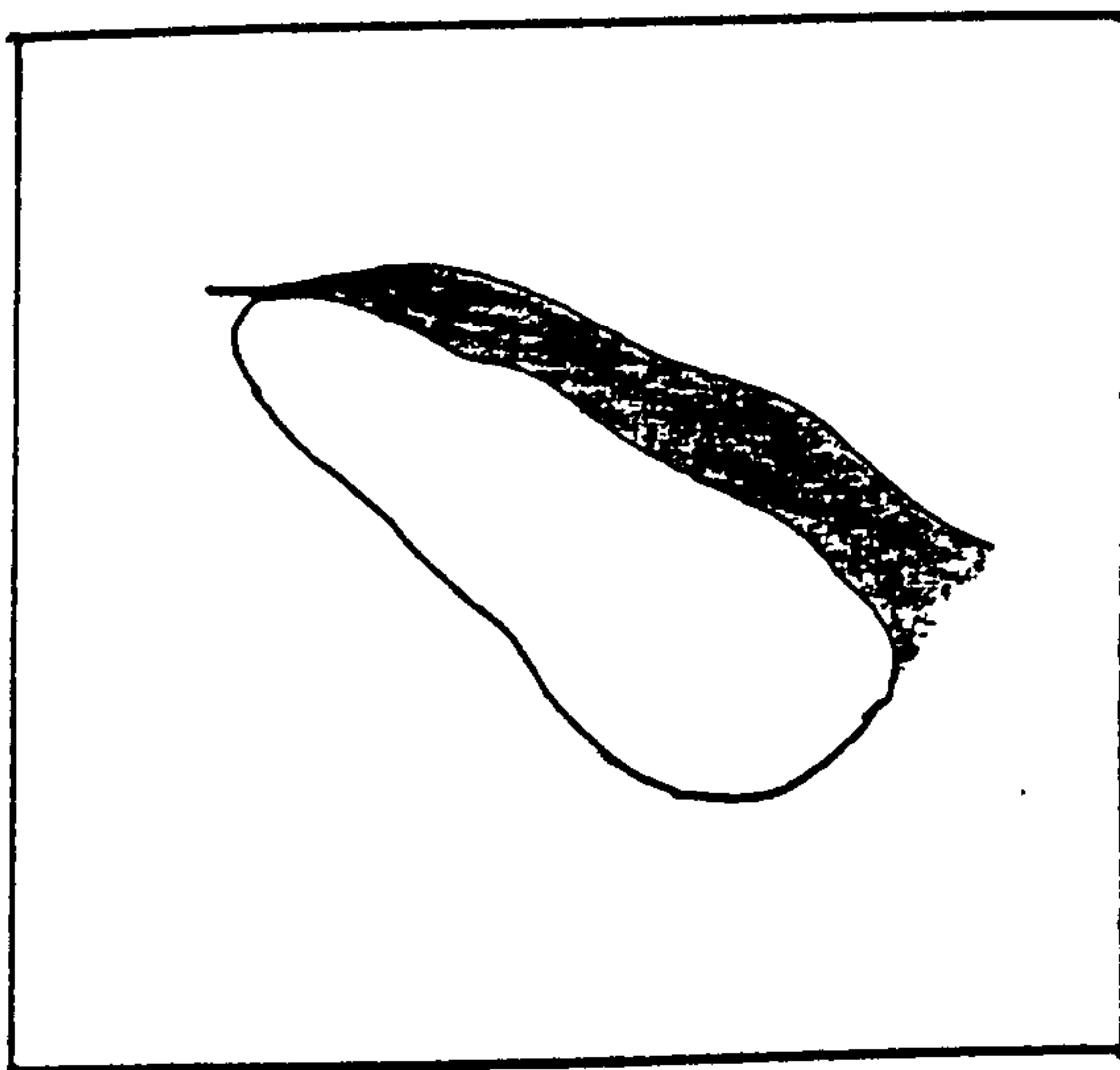
Figure 4. 17



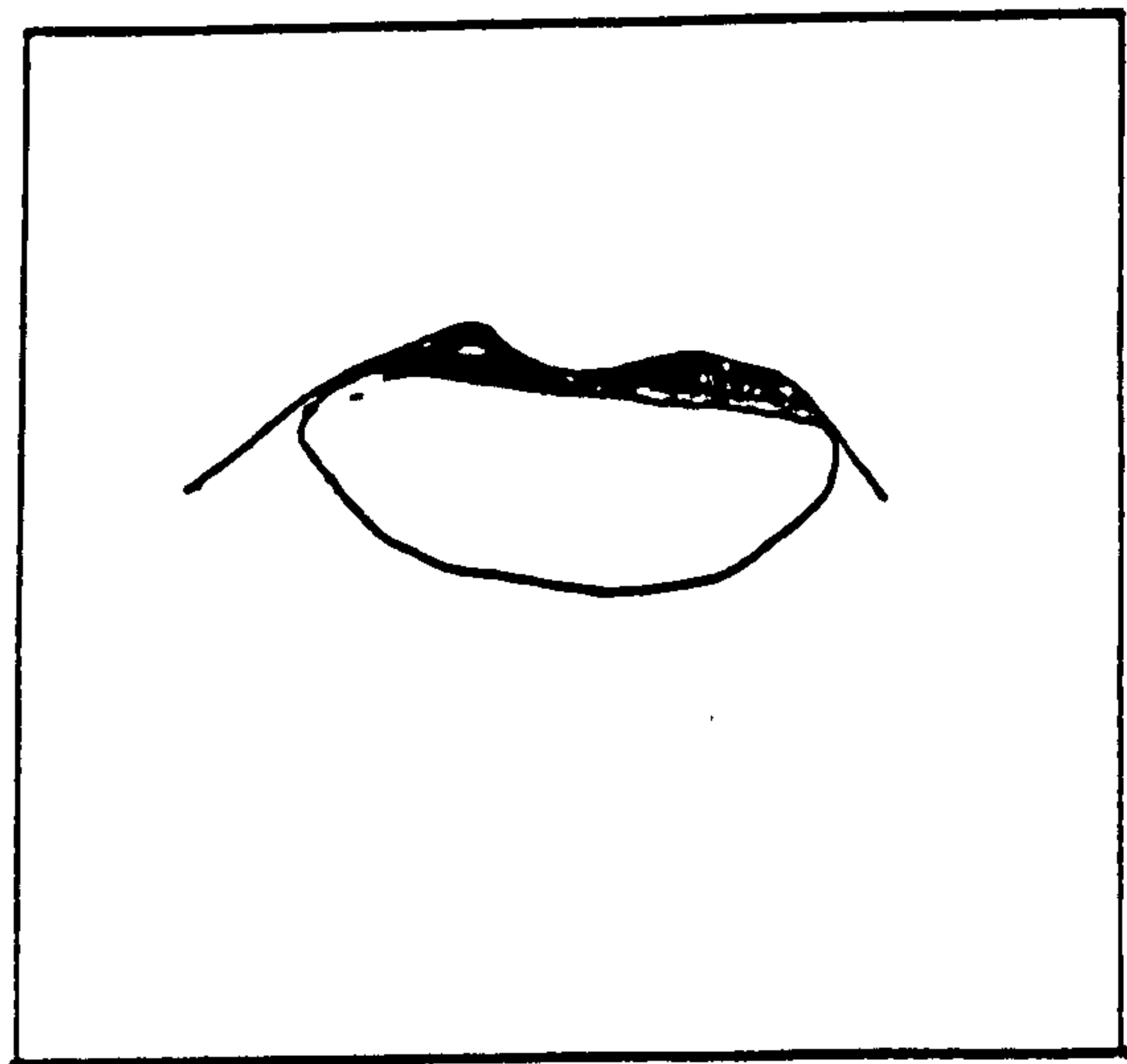
a.



b.



c.



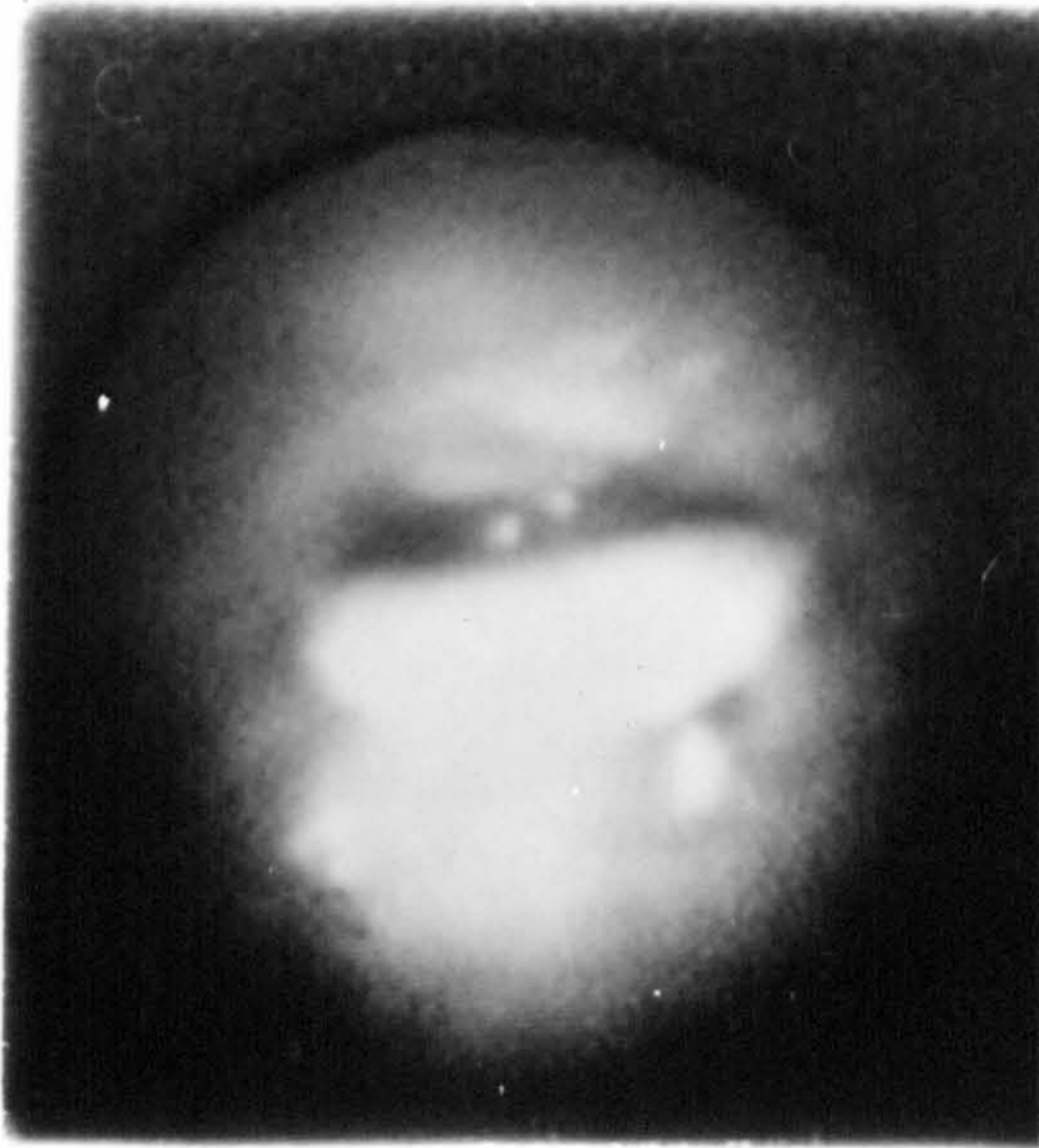
d.

Sketches of Figure 4.17

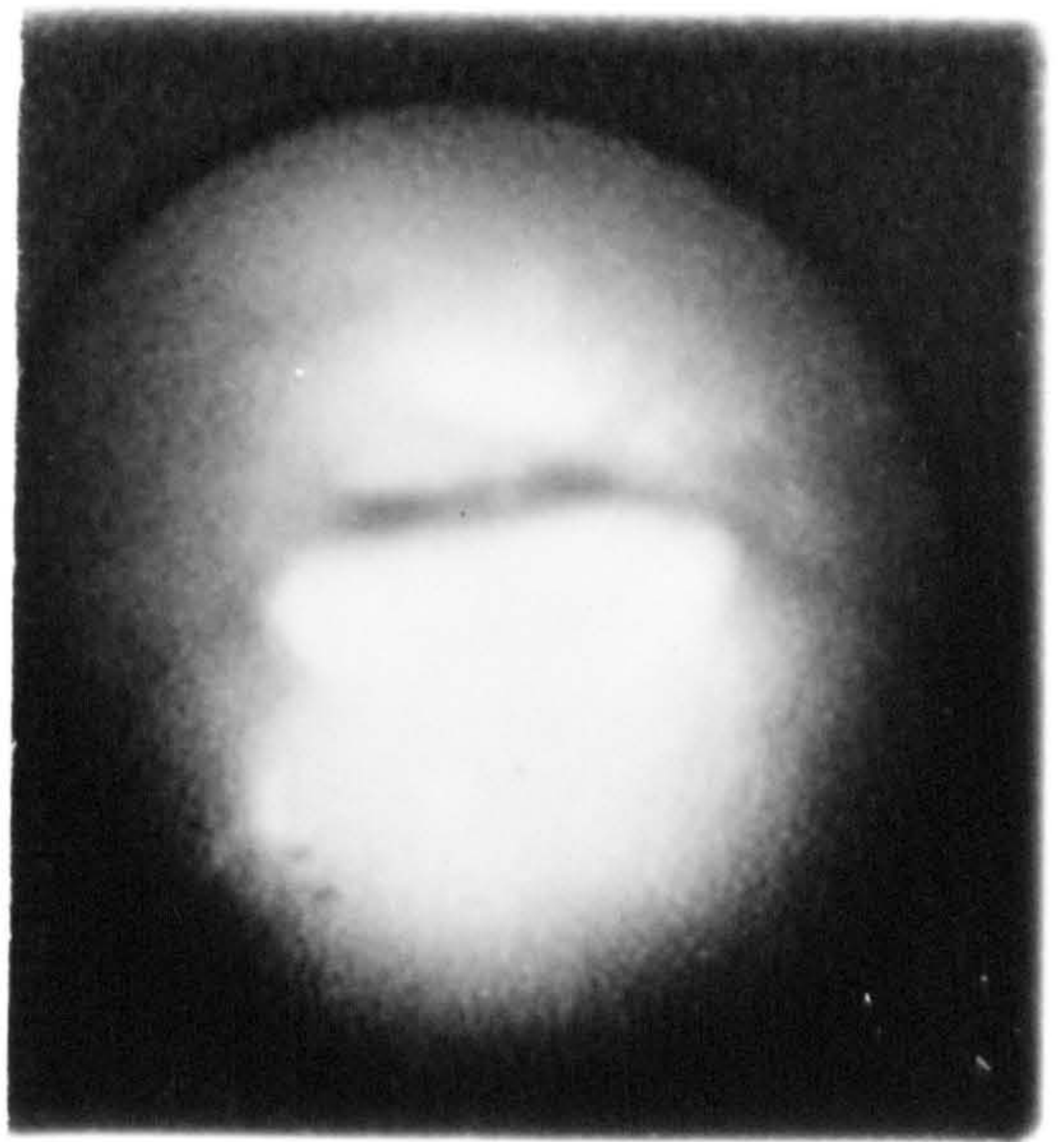
pharynx is wider for SA. The spectrogram of the same word as said by the subject (SA), shows that /ʒ/ is a voiceless stop. One might consider that the stop, in this case, is not made by the epiglottis against the back wall of the pharynx, but down in the larynx, but a possibility that must be considered is that because the opening that appears between the epiglottis and the back wall of the pharynx is very dark, a closure may be taking place just below the top of the epiglottis. That is, because the epiglottis curves at the top, only the curved part, which does not touch the pharyngeal wall appears.

In the examples of /saʒʒala/, as said by SA and WL, in Figures 4.17. a and b respectively, the constriction is slightly narrower than in /waʒd/ by WL. The gap between the epiglottis and the pharyngeal wall is very narrow for both subjects. The upper edge of the epiglottis is not uncurled.

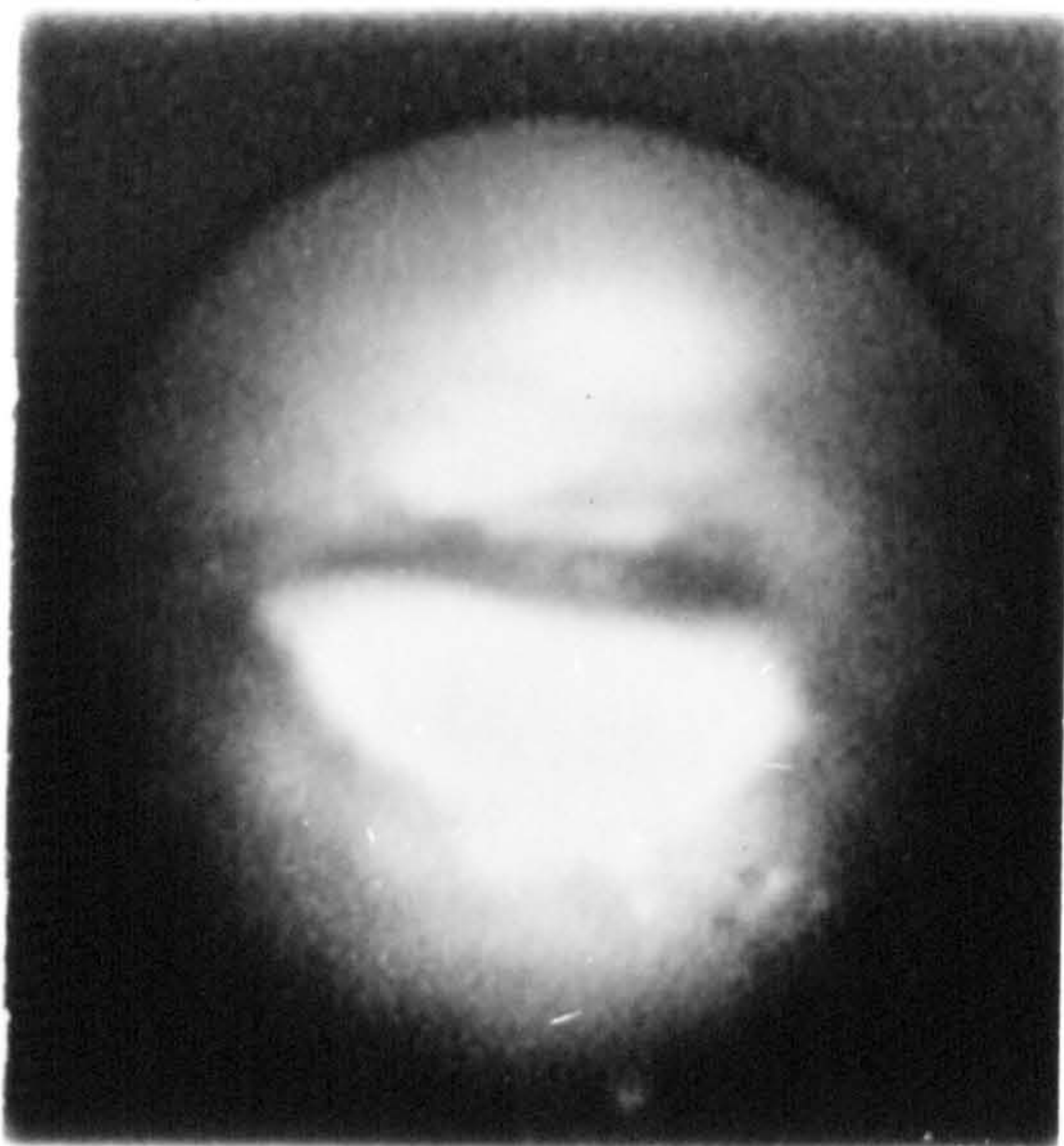
In Figures 4.18, 4.19 and 4.20, the pharyngeal consonants /ħ/ and /ʒ/ occur again in a medial position and geminated, by WL, SA and FL. Figures 4.18.a and c show a slight variation in the shape of constriction in /waħħada/ and /maħħana/ respectively, as said by WL. The epiglottis is only slightly uncurled in /waħħada/. In b and d of /waʒʒada/ and /maʒʒana/, the constriction for /ʒʒ/ is narrower than that for /ħħ/. In the case of the examples of SA of the same words in Figure 4.19, the constrictions



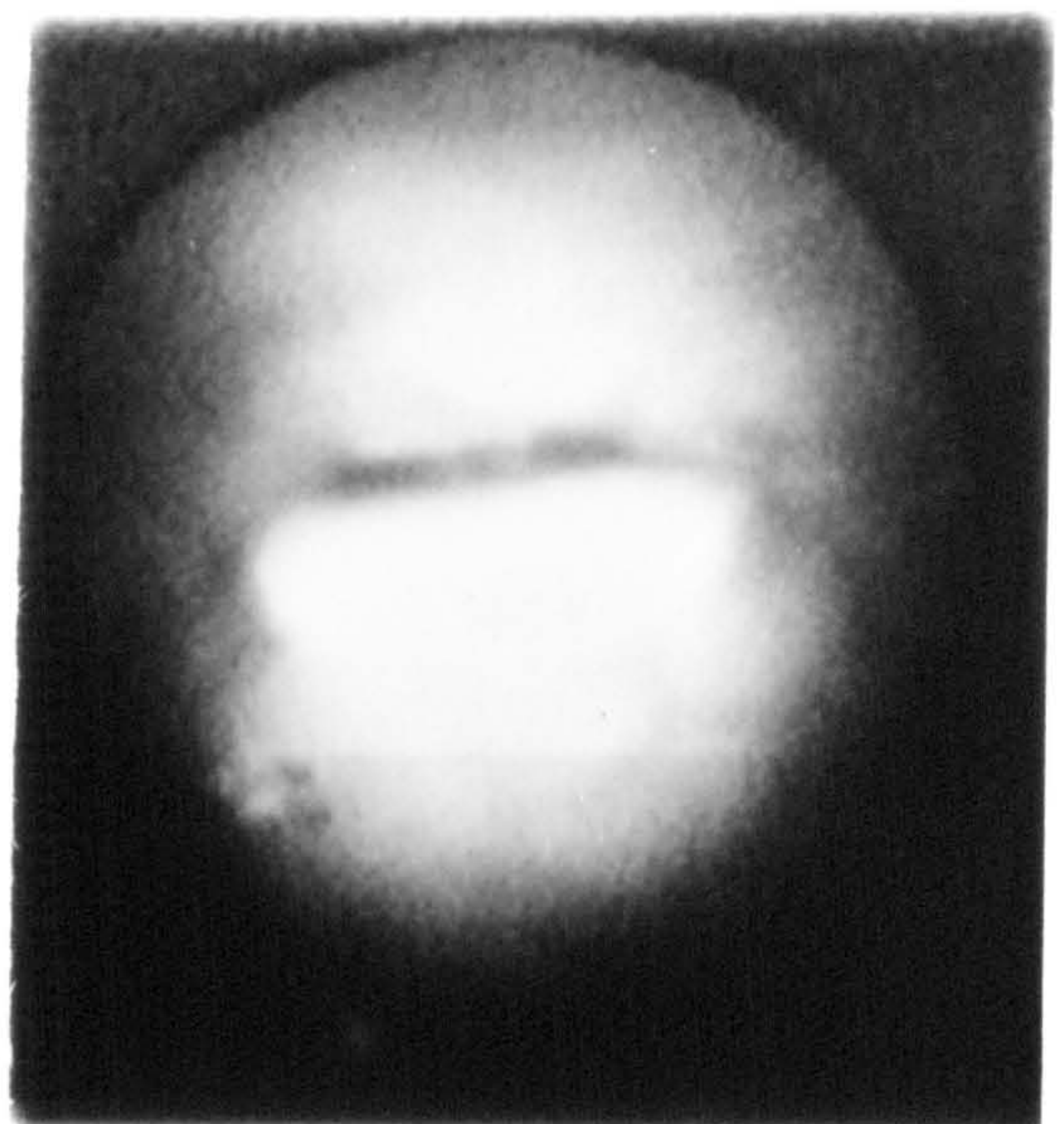
a. /w/ in /wawwada/ (WL)



b. /3/ in /wa33ada/ (WL)

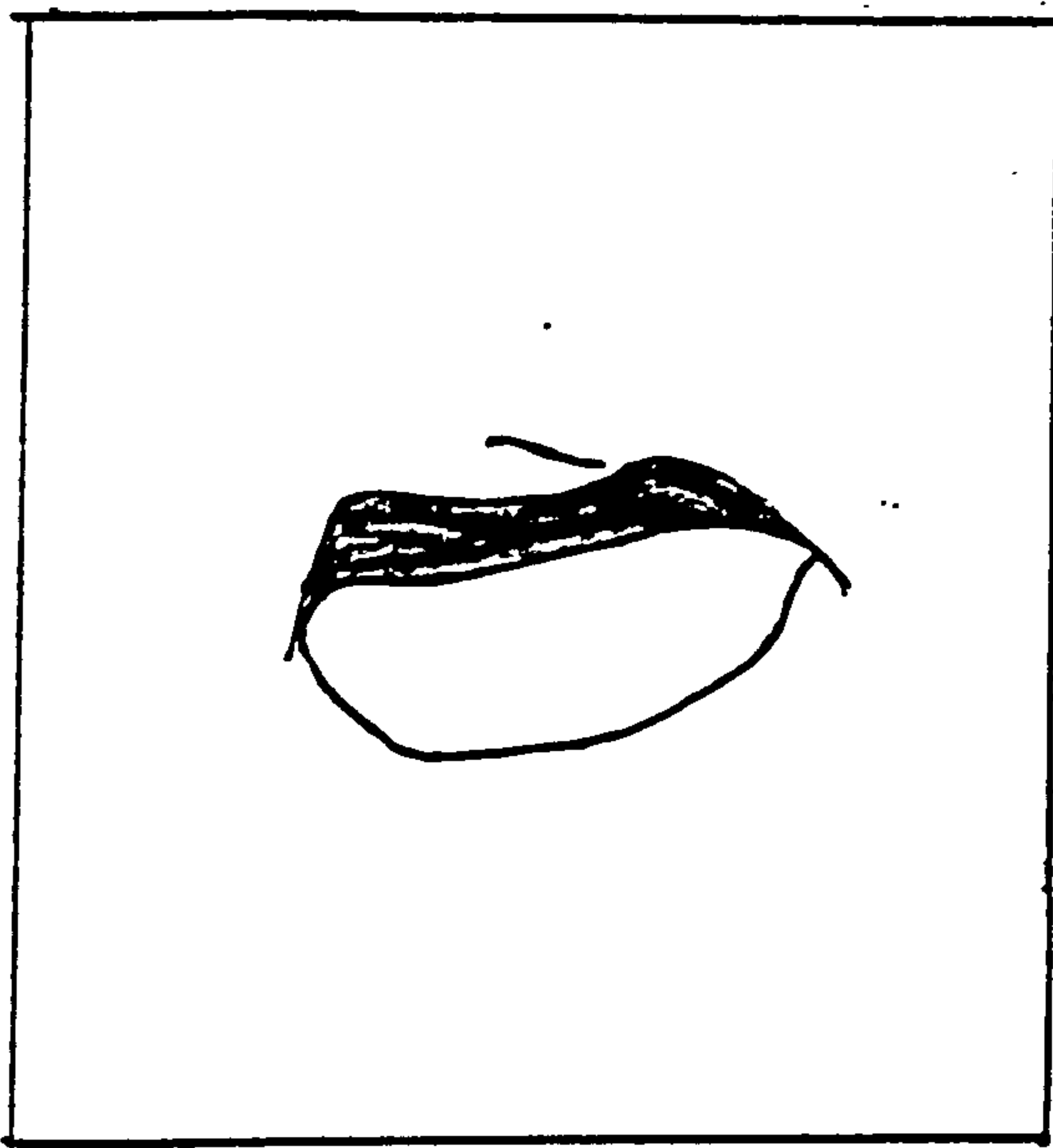


c. /w/ in /mawwana/ (WL)

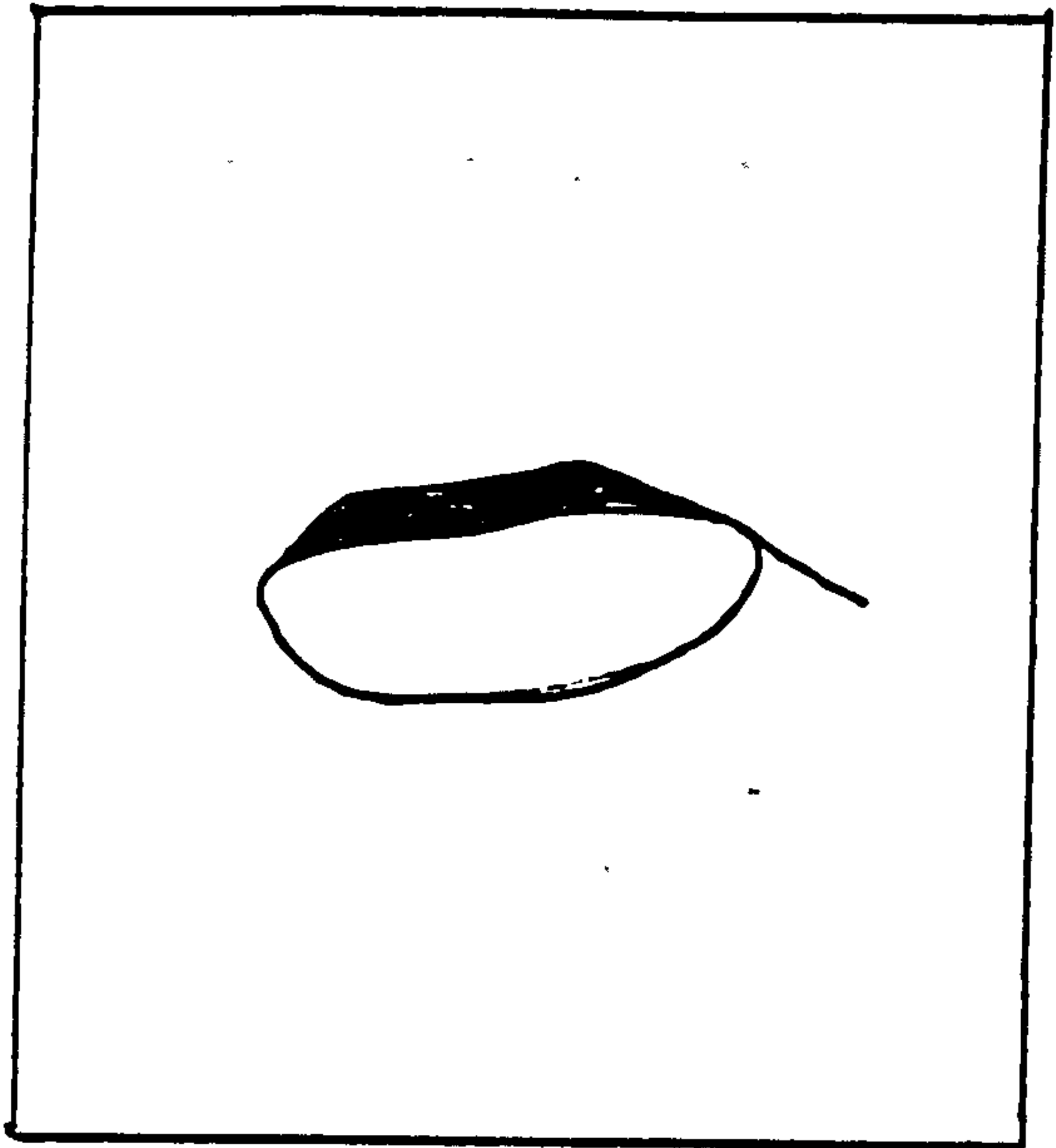


d. /3/ in /ma33ana/ (WL)

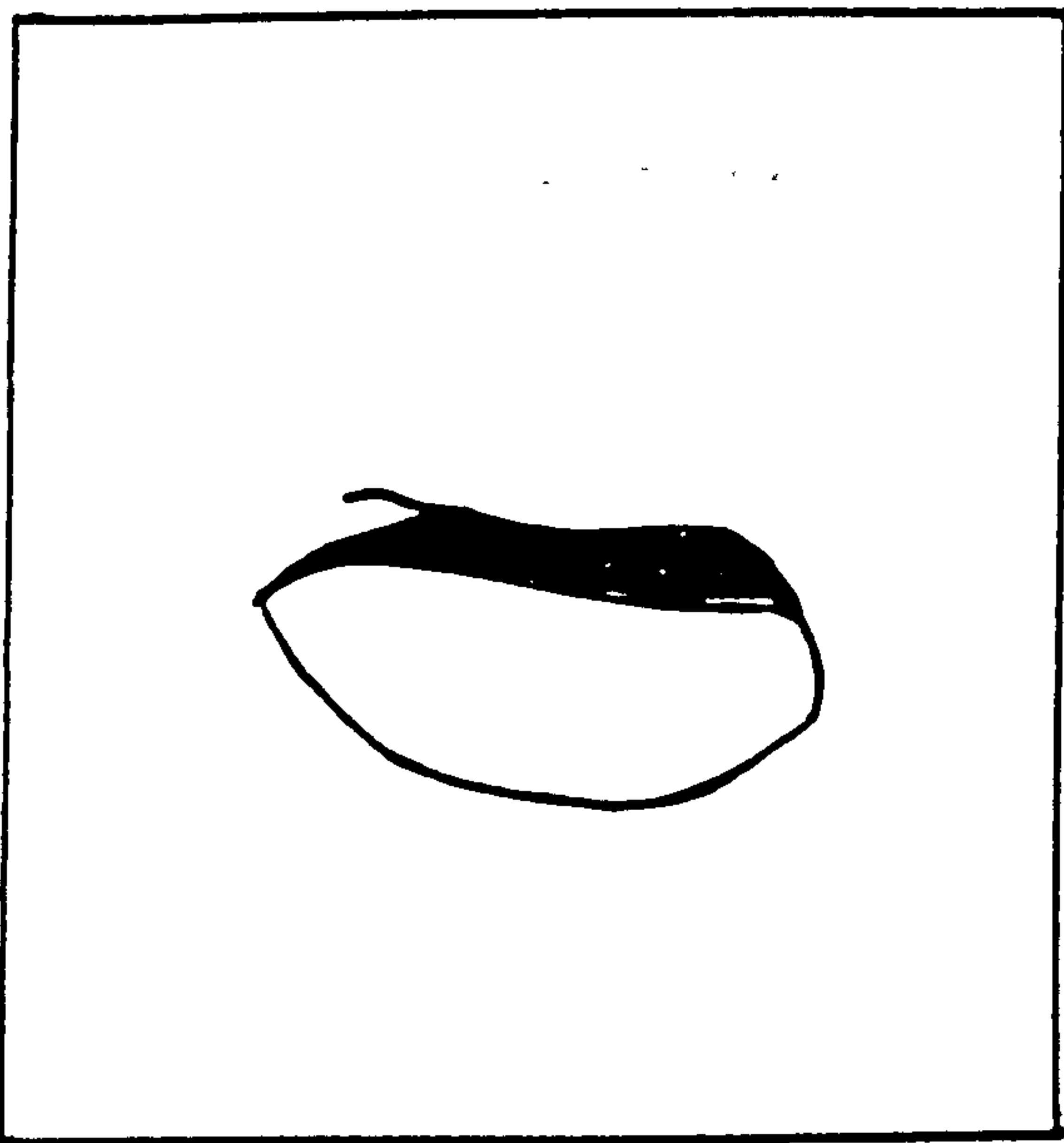
Figure 4.18



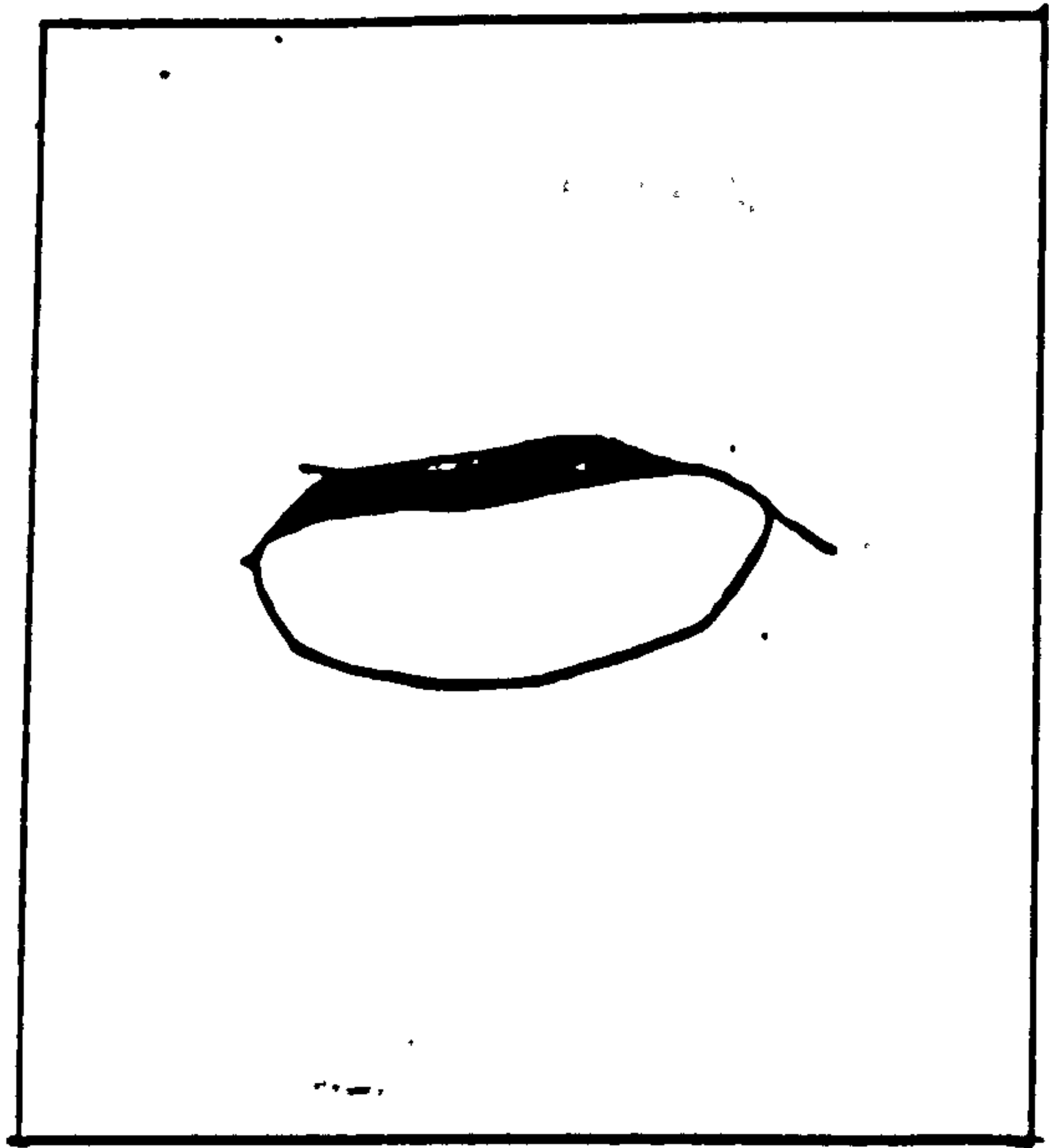
a.



b.

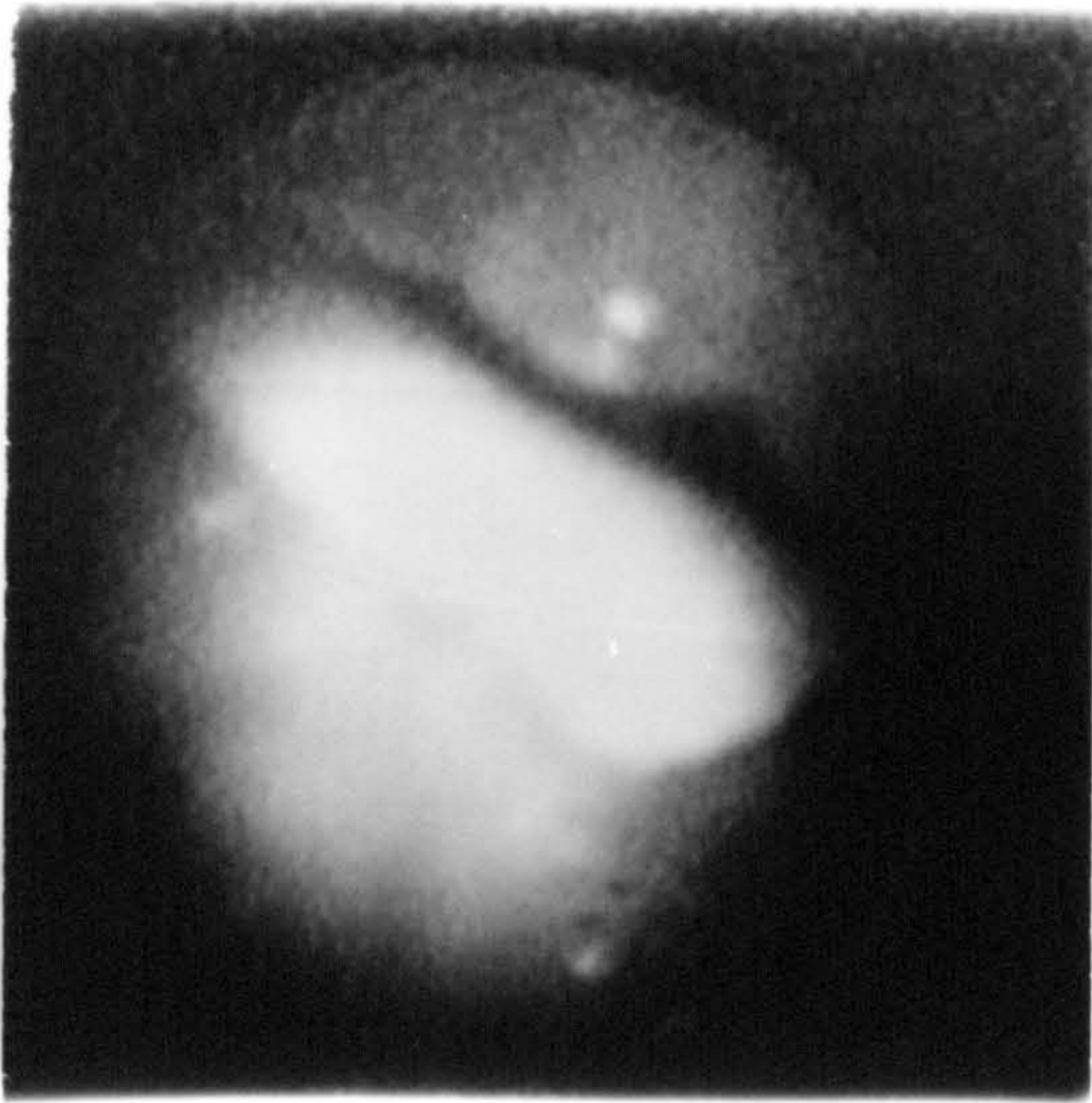


c.

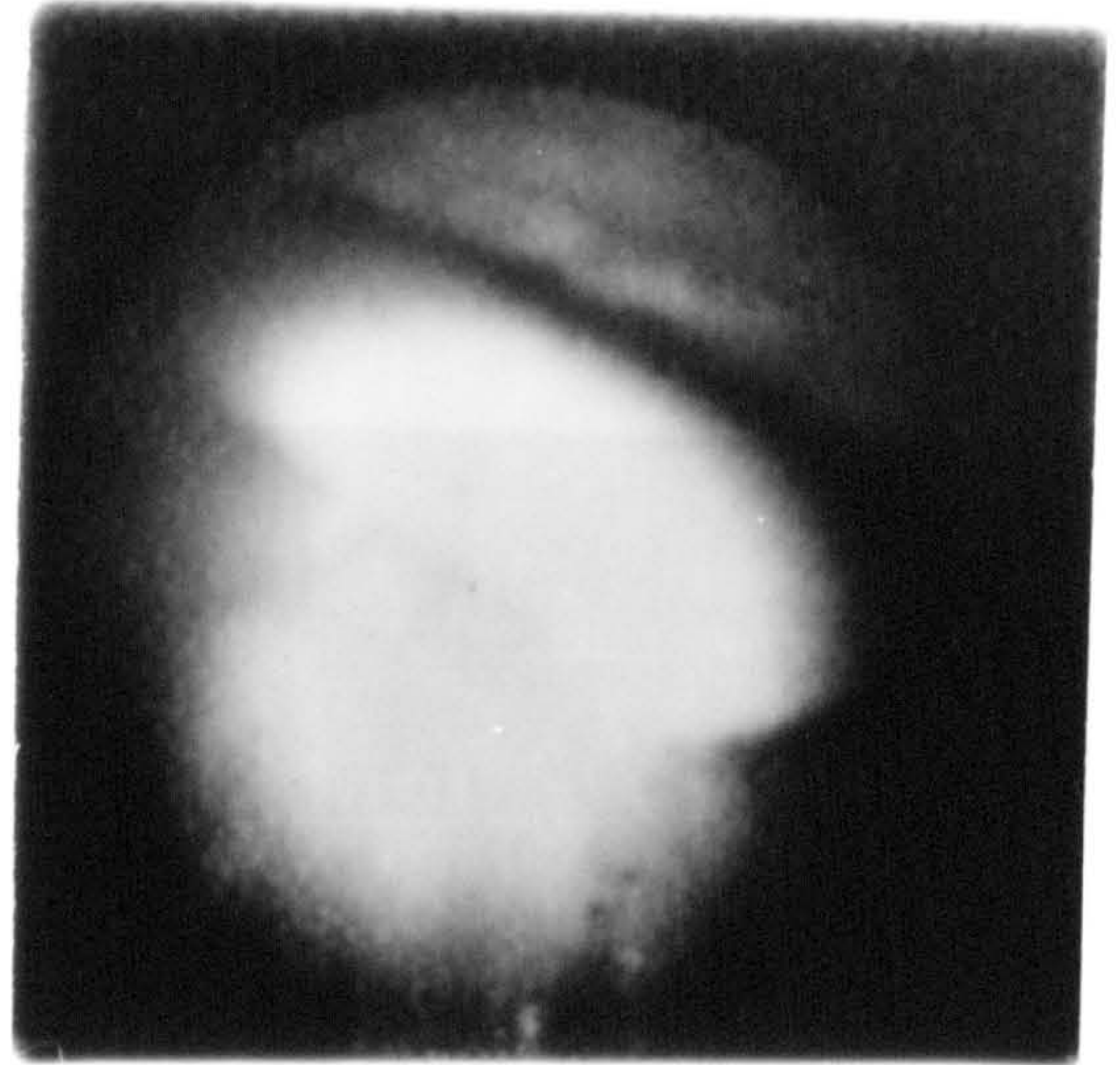


d.

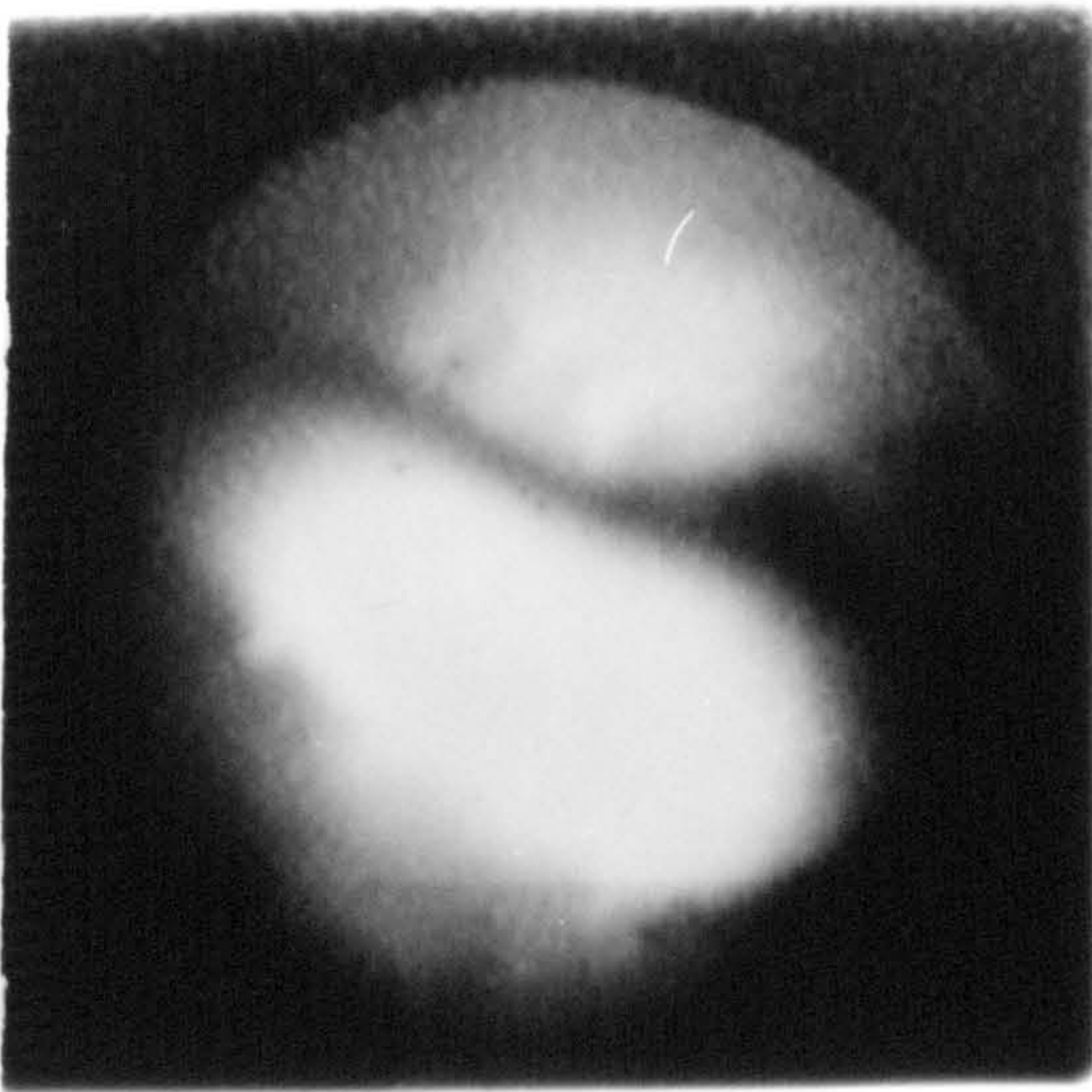
Sketches of Figure 4.18



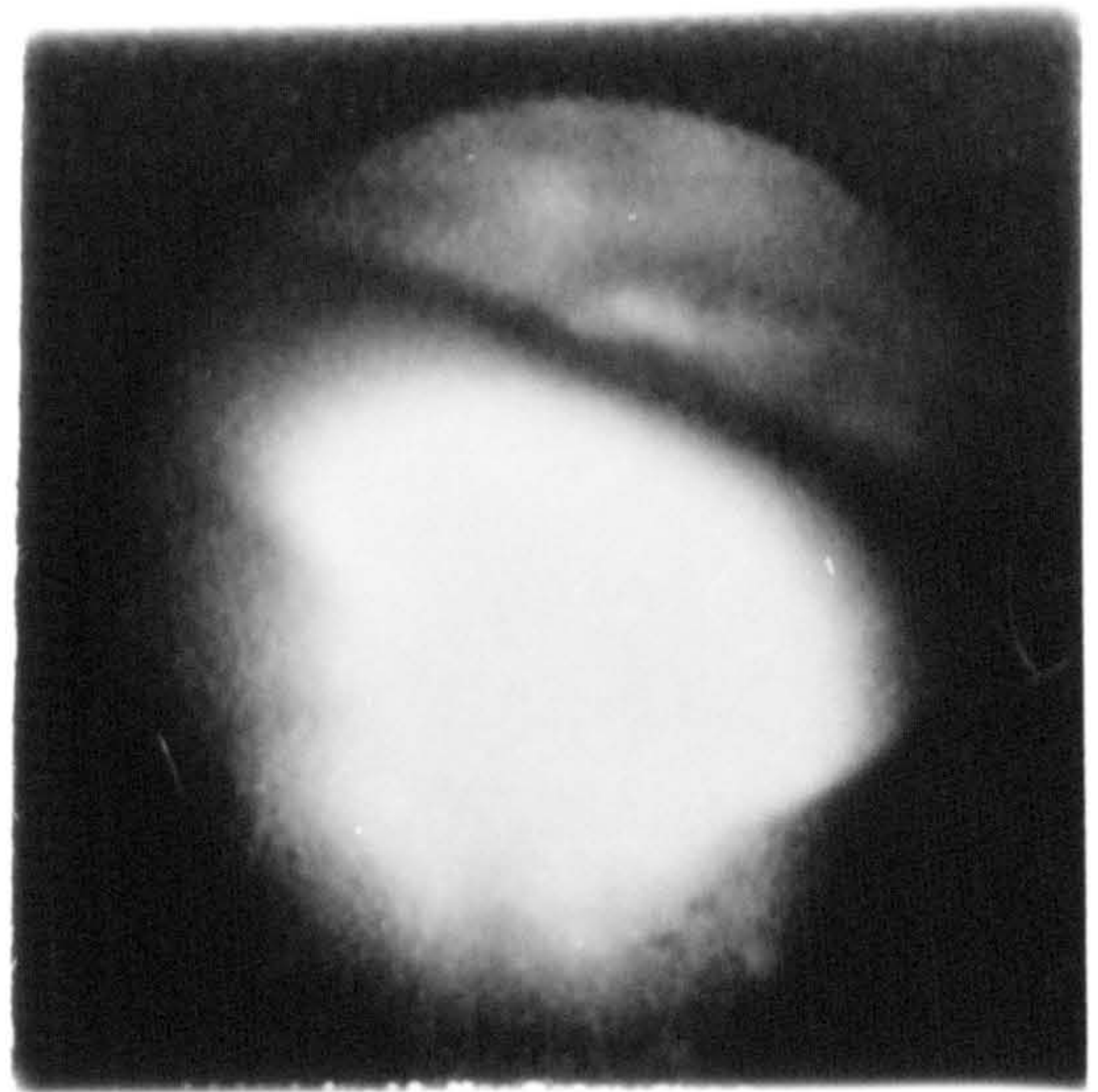
a. /ɨ/ in /waɨɨada/ (SA)



b. /ɜ/ in /waɜɜada/ (SA)

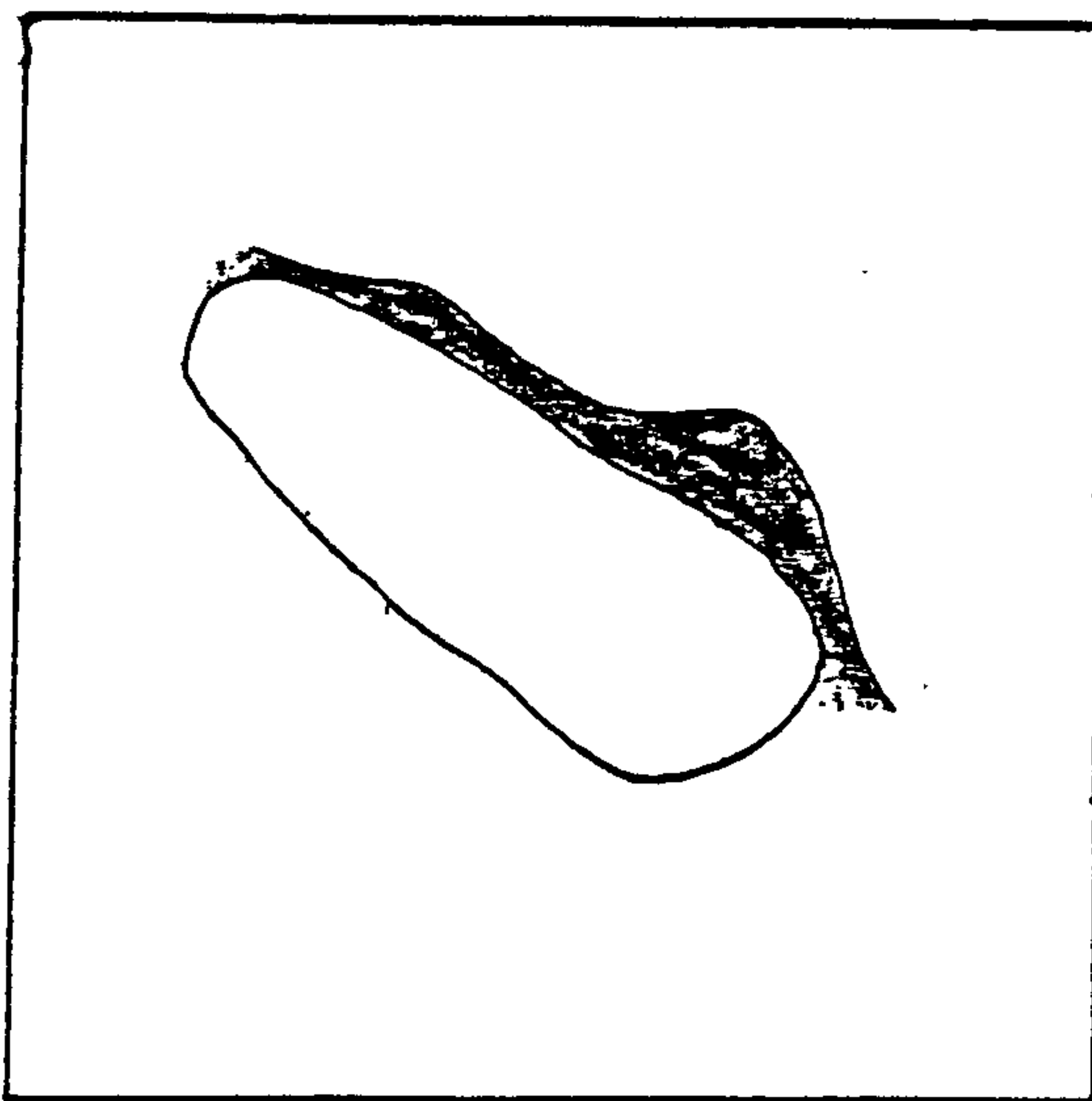


c. /ɨ/ in /maɨɨana/ (SA)

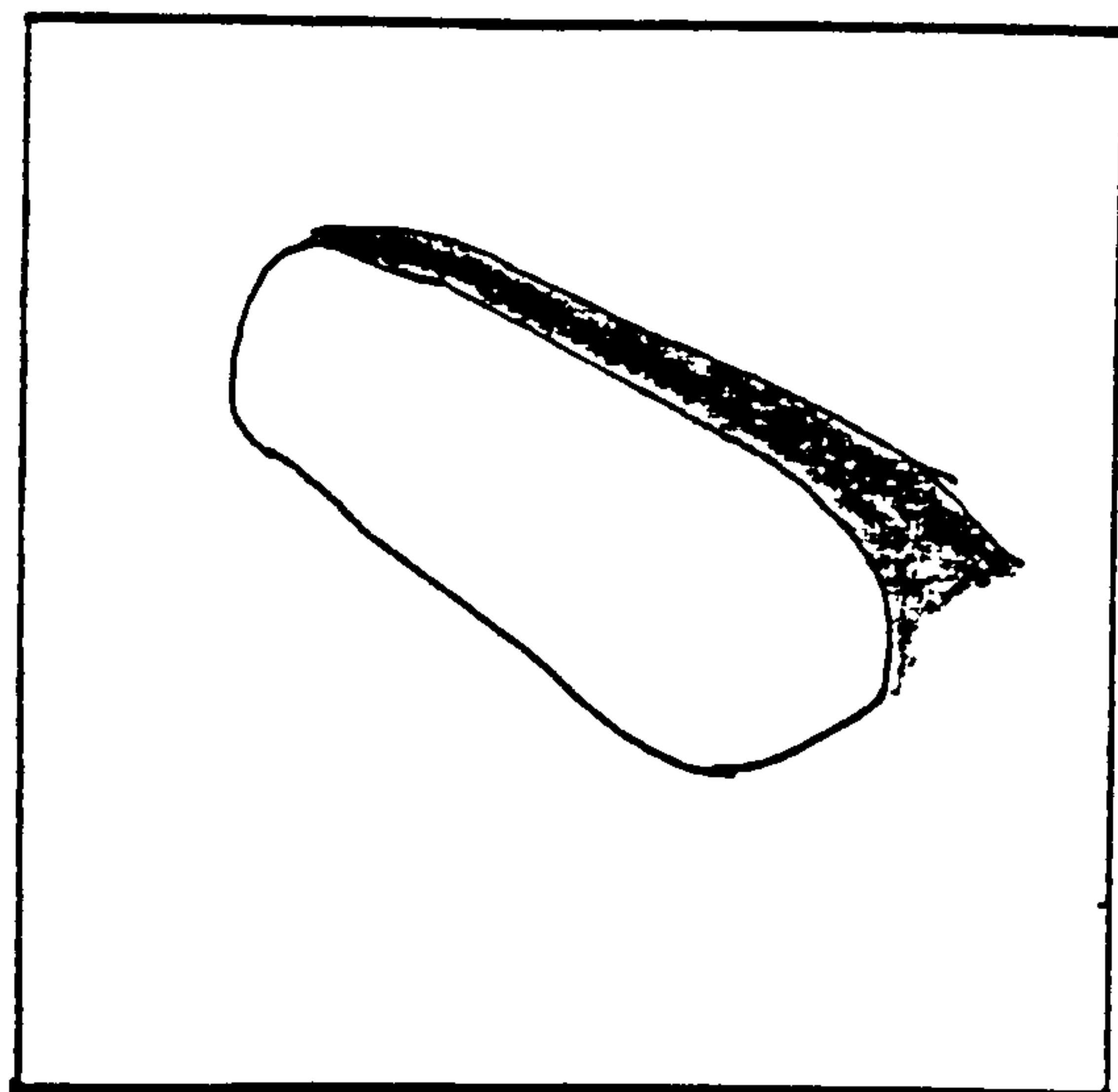


d. /ɜ/ in /maɜɜana/ (SA)

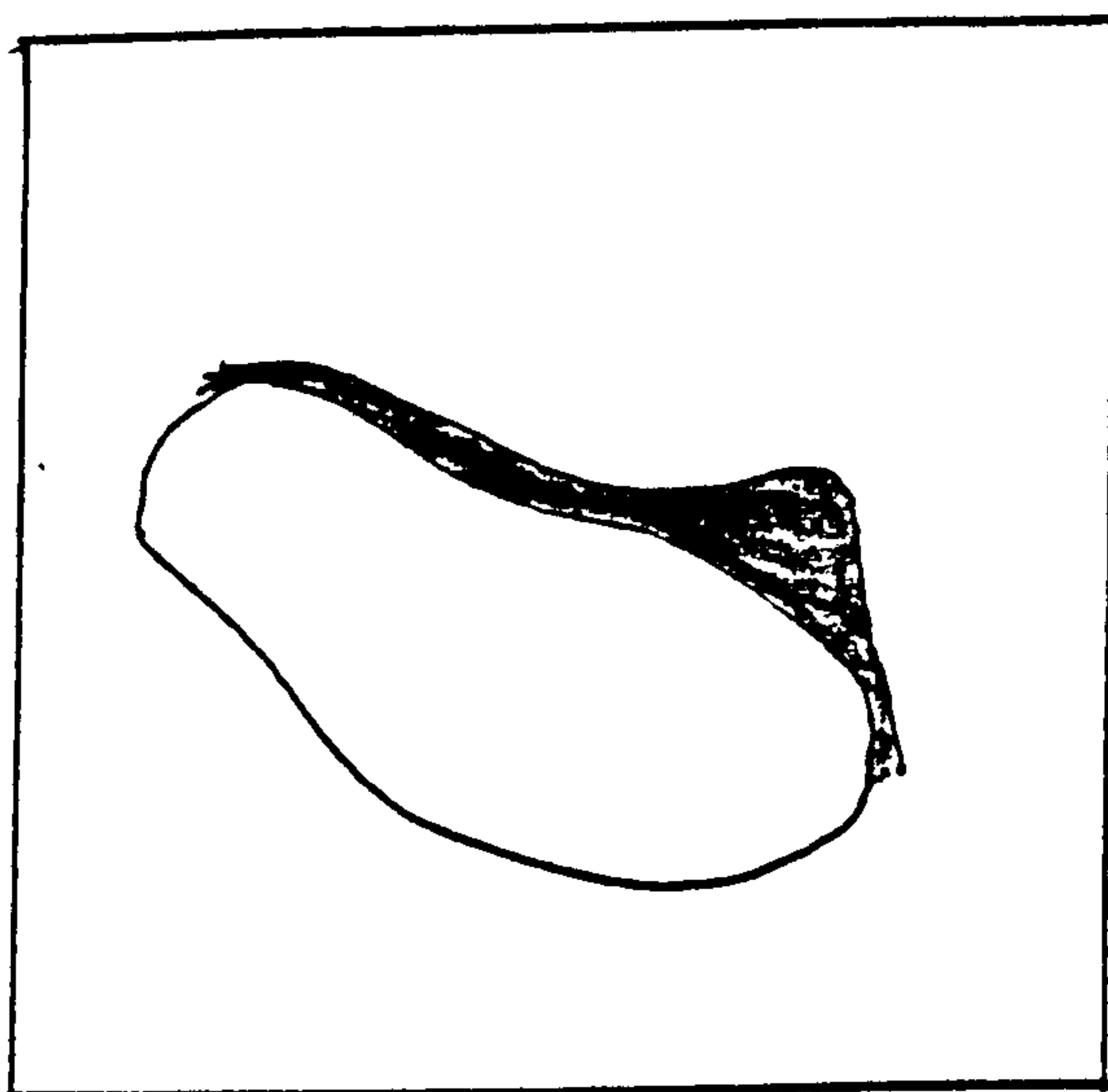
Figure 4.19



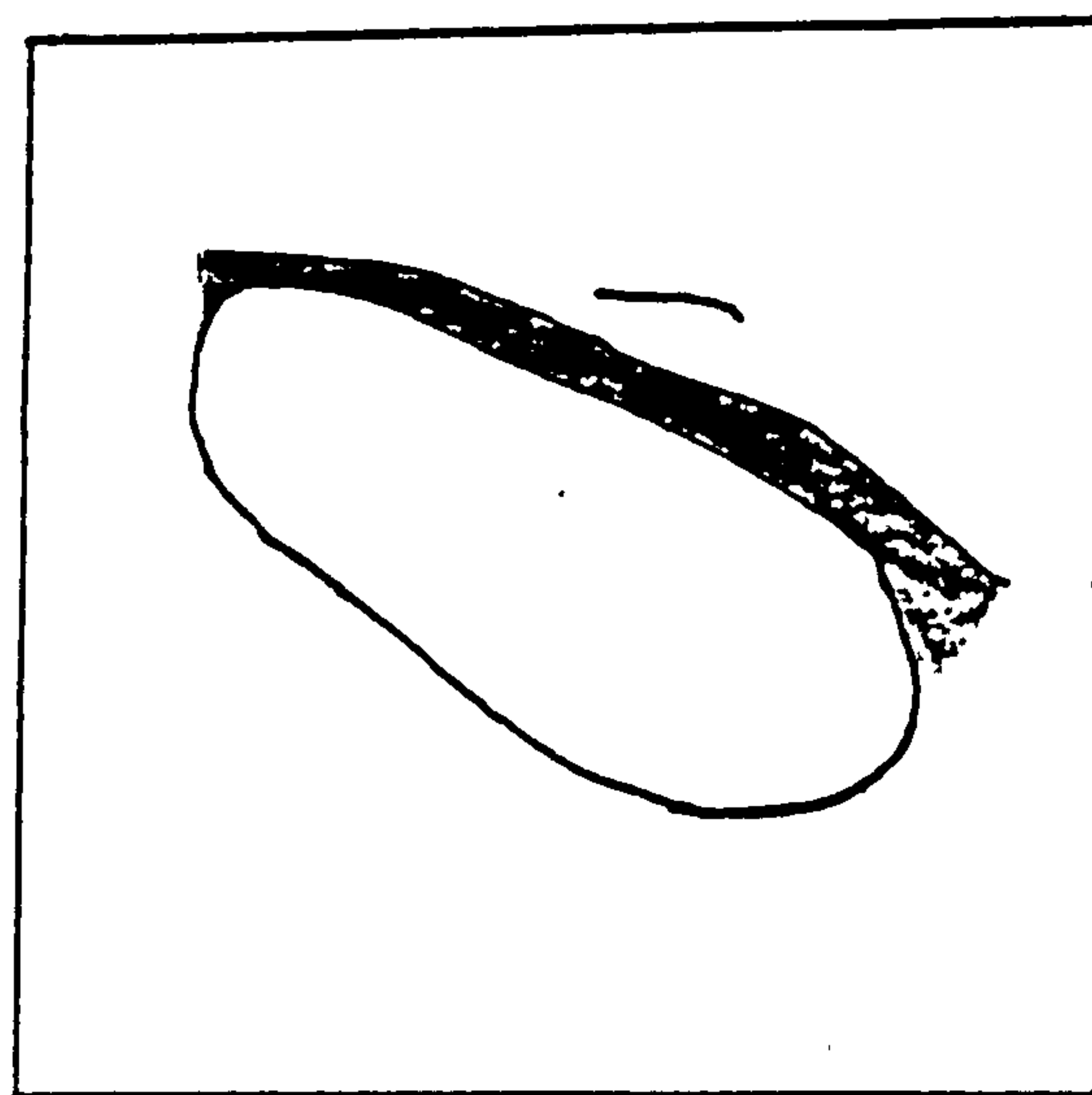
a.



b.



c.



d.

Sketches of Figure 4.19

for /wa~~h~~ada/ and /ma~~h~~ana/ a. and c respectively are almost exactly the same, and this applies to /wa33ada/ and /ma33ana/ in b and d respectively. In the four examples, the constriction is quite considerable.

The examples shown in Figure 4.20 of the medial geminated /~~h~~/ and /33/ are of two stages of the articulation of these sounds. In a and b of /~~h~~/ in /wa~~h~~ada/, the constriction in the lateral wall of the pharynx and the retraction of the epiglottis increase from a to b. This is also evident in c and d of /33/ in /wa33ad/.

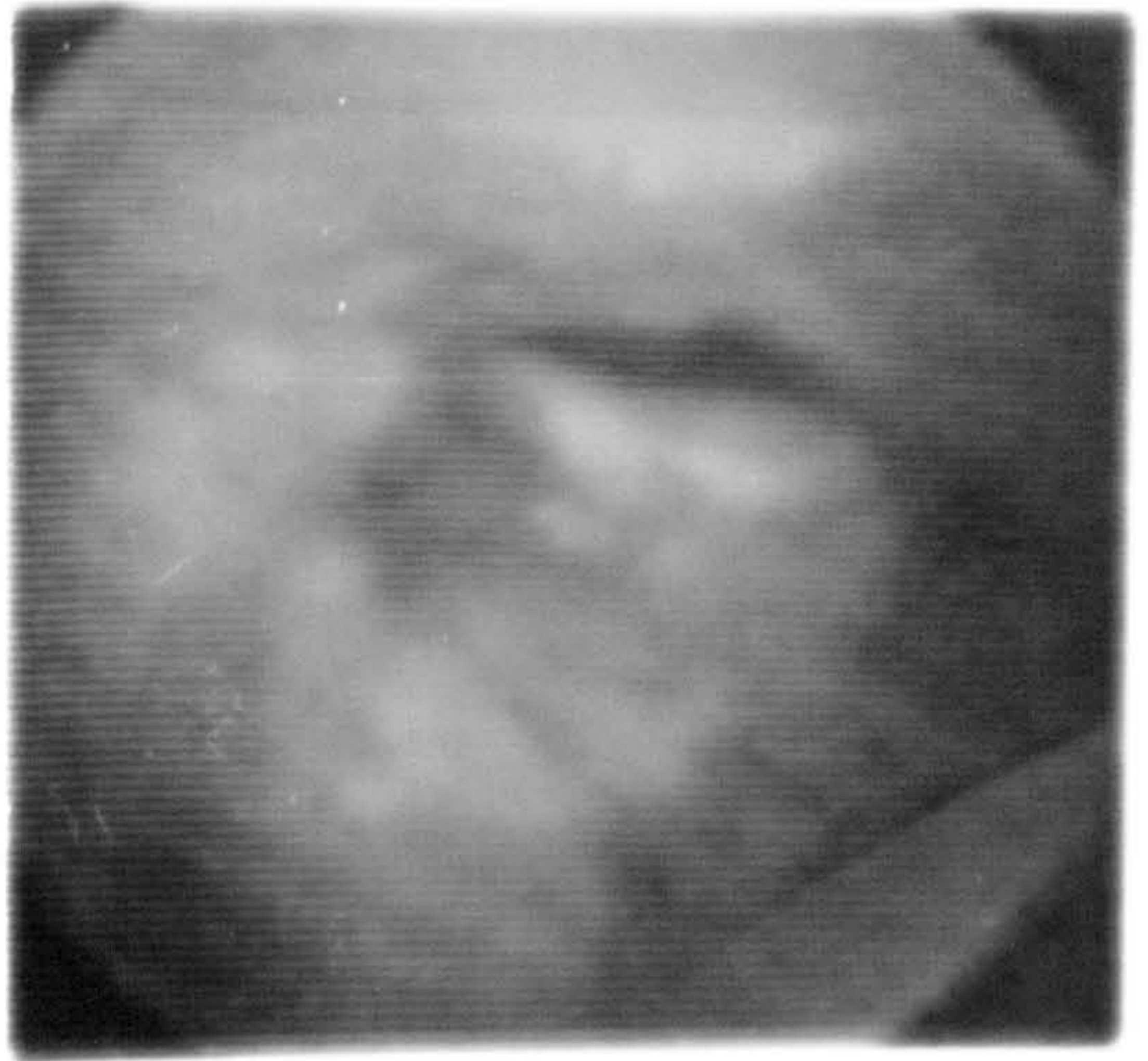
The variations that occur in the pharynx during the articulation of the pharyngeal consonants /~~h~~/ and /3/ are not consistent, but in general a great constriction is observed to occur during the articulation of these sounds in all subjects.

Airflow analysis

Aerograms of the voiceless pharyngeal fricative /~~h~~/ in an initial, medial or final position in a word, as said by FL, all show significant nasal flow whether a nasal sound is present or not. The ratio of average flow rate through the nose to that through the mouth for /~~h~~/, however, varies from one person to another with the maximum flow where it is in medial position in the word and geminated. This was observed for both subjects (FL and WL).



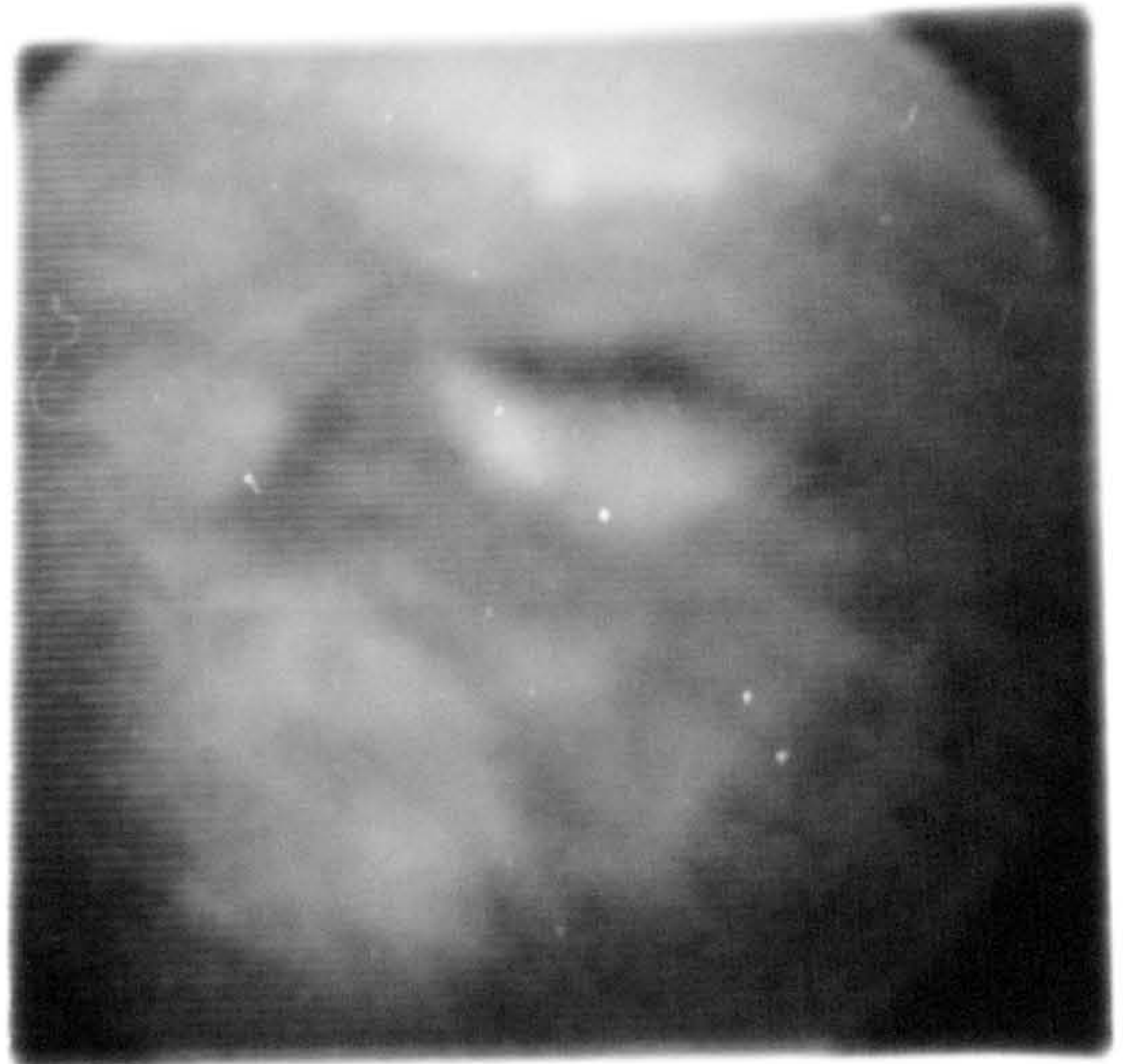
a. /ɨ/ in /waɨɨada/ (FL)



b. /ɨ/ in /waɨɨada/ (FL)

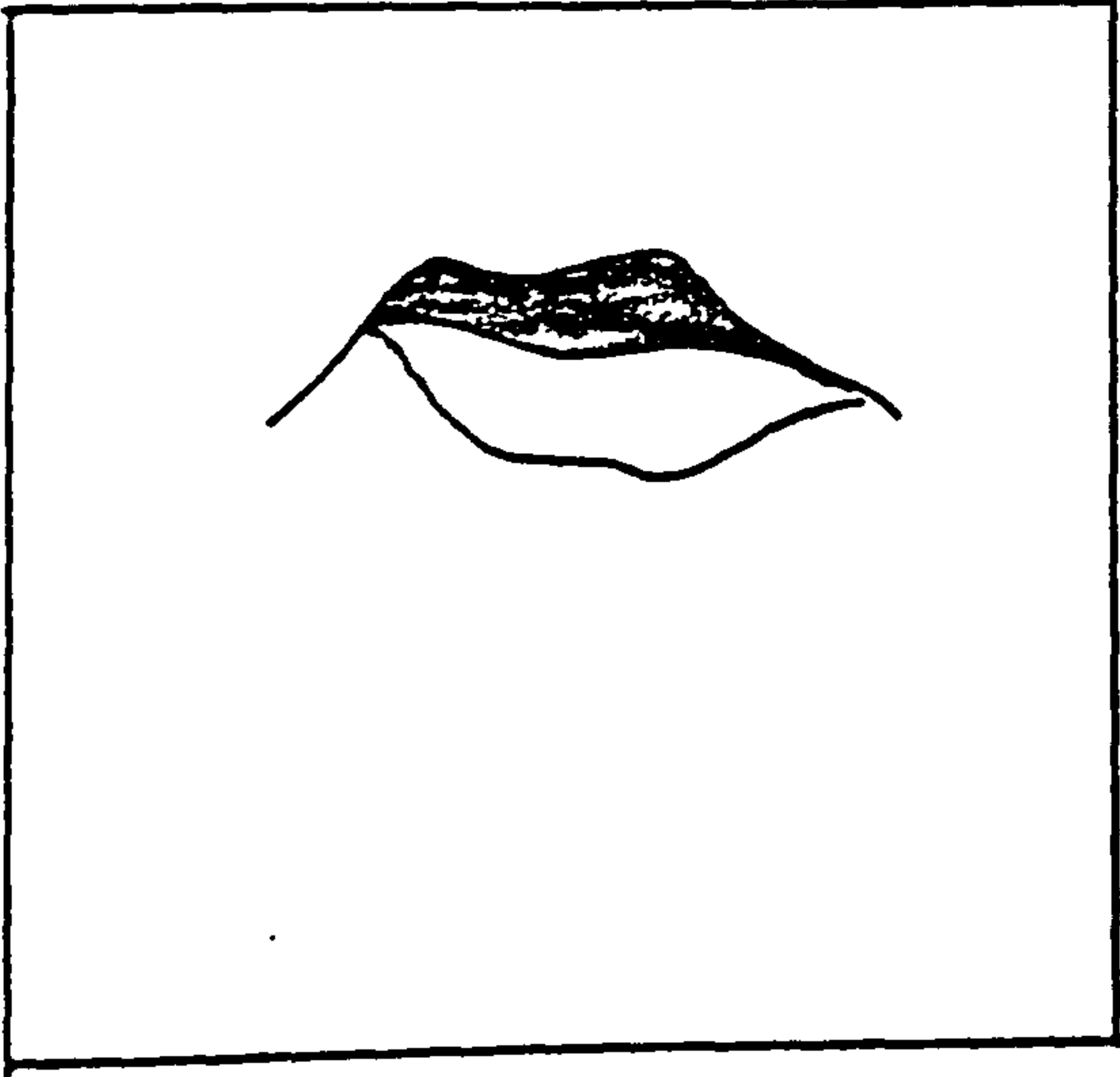


c. /ɜ/ in /waɜɜad/ (FL)

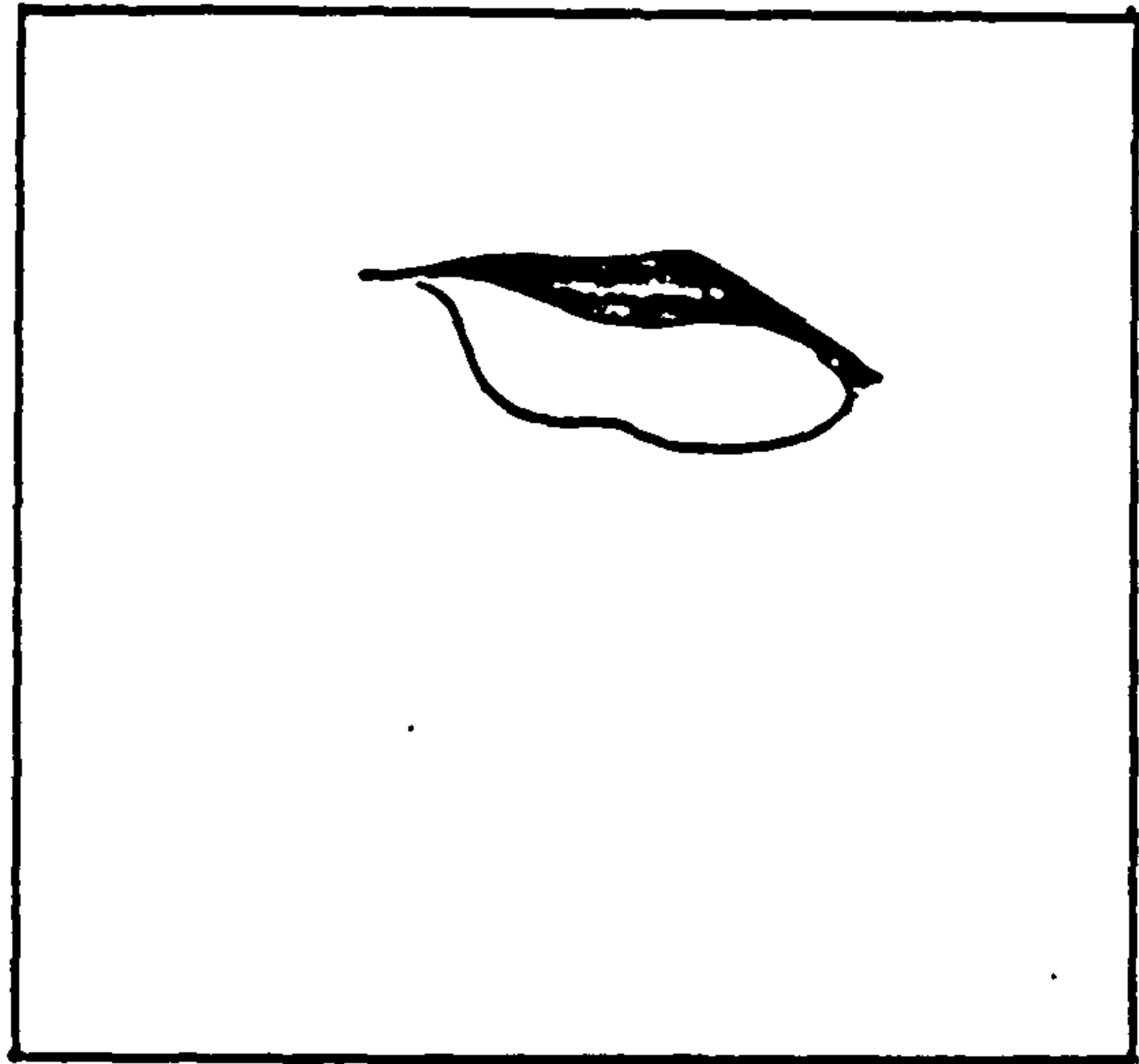


d. /ɜ/ in /waɜɜad/ (FL)

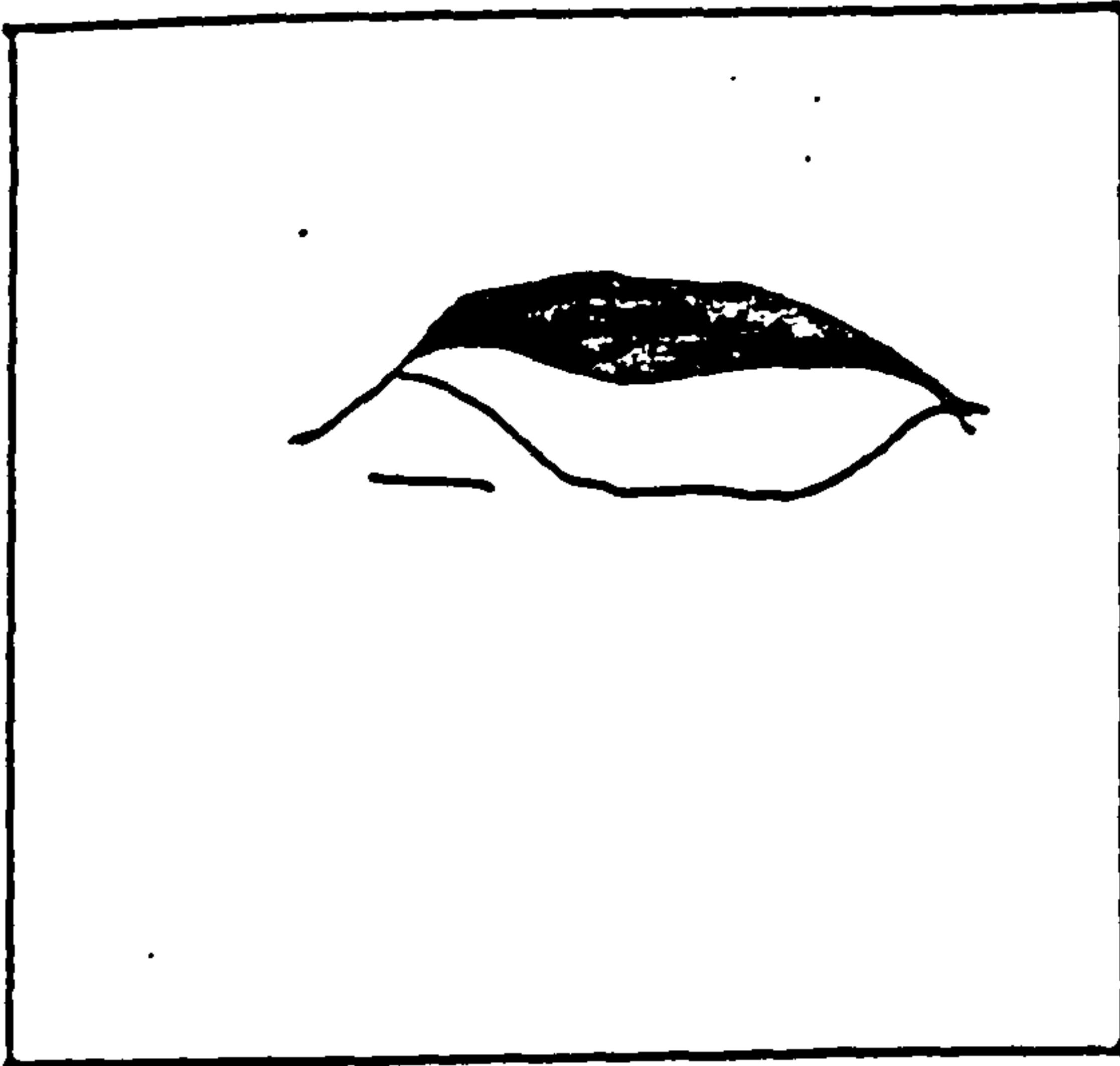
Figure 4.20



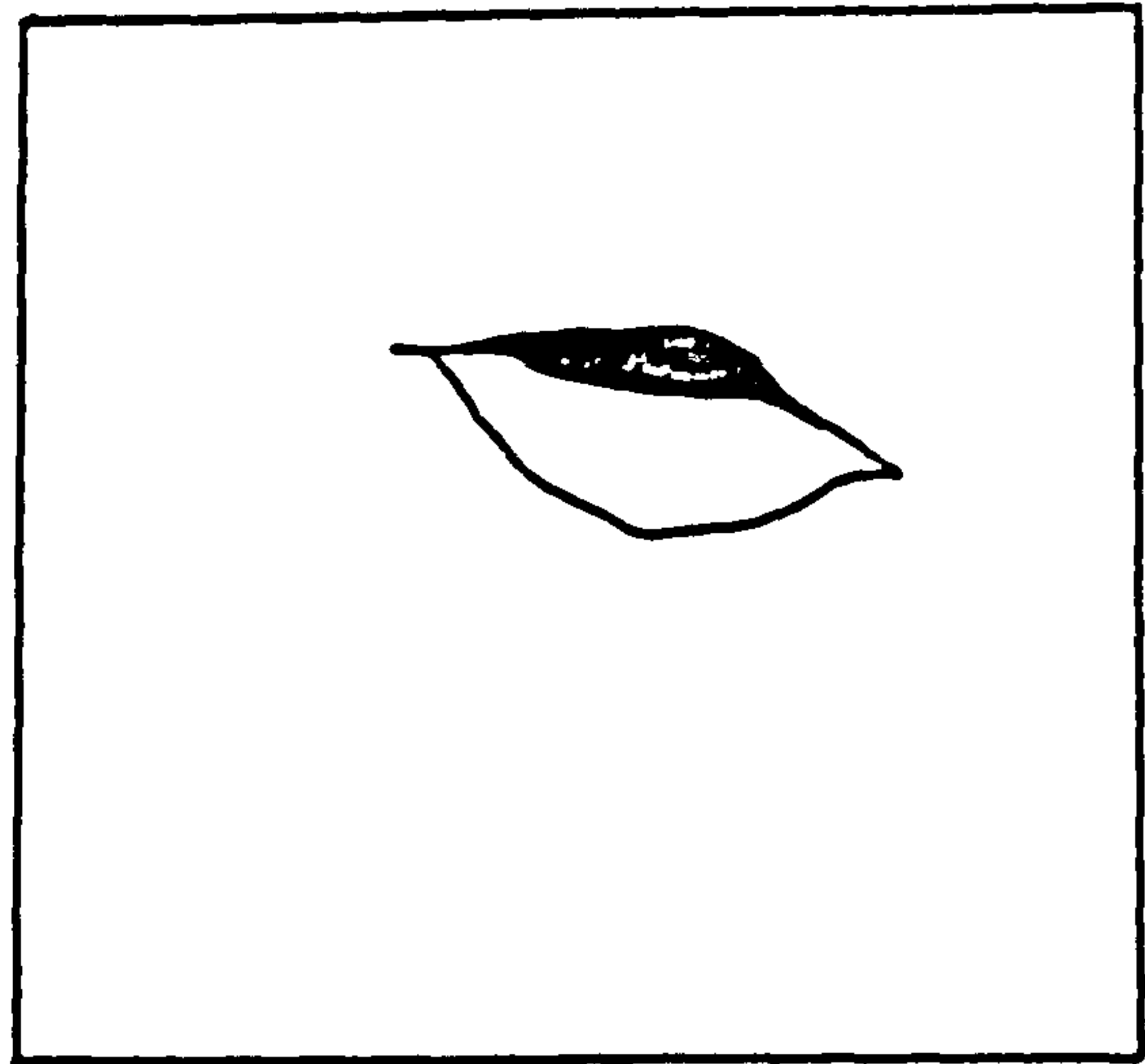
a.



b.



c.



d.

In Figure 4.21 of the word /na~~h~~na/, as said by FL, the first segment /n/ is devoiced initially. Almost the same nasal flow is present for the following vowel /a/. When voicing ceases during the articulation of the next segment /~~h~~/ (208 ms duration), the average nasal flow over this segment is 130 ml/s. There is a linear increase in flowrate over the first 40 ms to a peak flow of about 360 ml/s decreasing in the middle of the /~~h~~/ segment to 70 ml/s before rising again to about 180 ml/s at start of voicing. This pattern is repeated almost exactly for the same word said by the same subject. This airflow pattern of the voiceless pharyngeal /~~h~~/ can be compared to its voiced counterpart /ʒ/ in /maʒʒana/. Figure 4.22 shows this sound medial and geminated where the initial segment is again a nasal. In this case, however, there is also a nasal airflow, but here the oral flow is reduced almost to zero. Nasal flow for this segment /ʒʒ/ is 70 ml/s.

When /~~h~~/ occurs in a medial position in a word, and non-geminated, Figure 4.23, of /ra~~h~~a/, the typical pattern of /~~h~~/ in medial position and geminated is almost repeated here but much shorter. The peak flow rate through the nose for /~~h~~/ is 80 ml/s, decreasing gradually until it is reduced to zero shortly after the start of the final vowel. It is interesting to note the increase of 'voiced friction' where voicing continues as flow increases - possibly under the influence of the vowel /a/ - at the beginning of /~~h~~/. Oral airflow here is minimum. In /raʒa/, Figure 4.24,

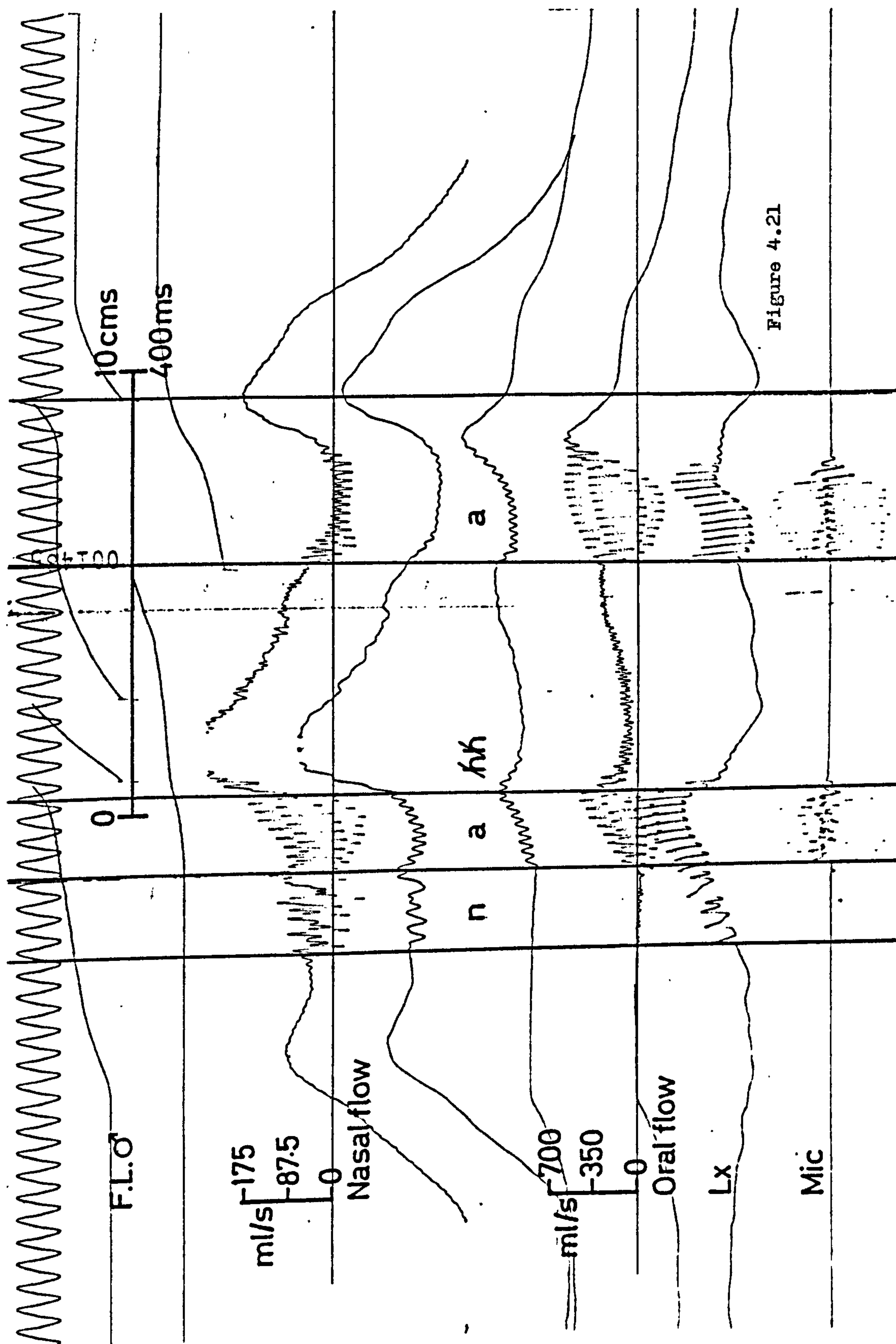


Figure 4.21

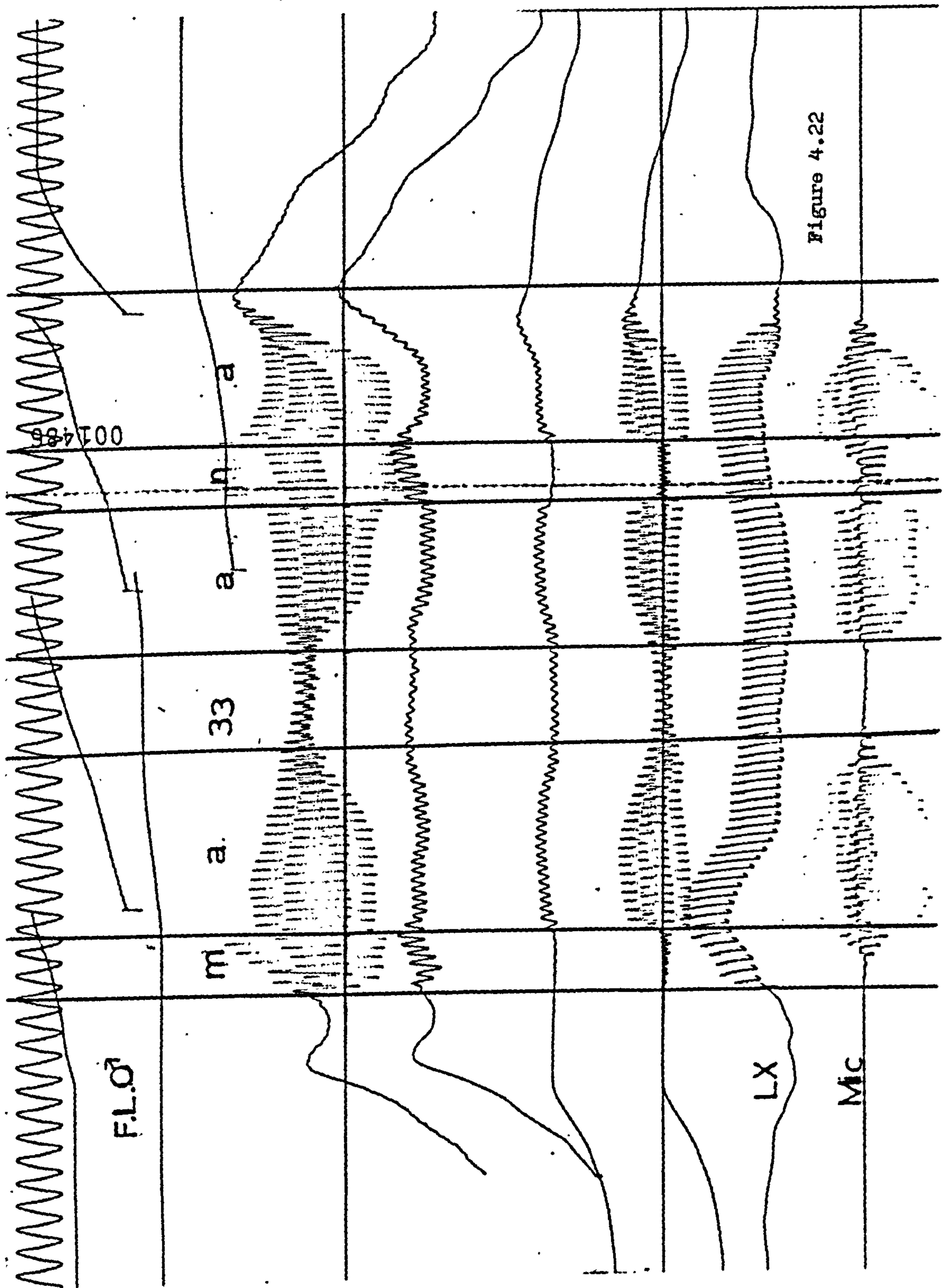
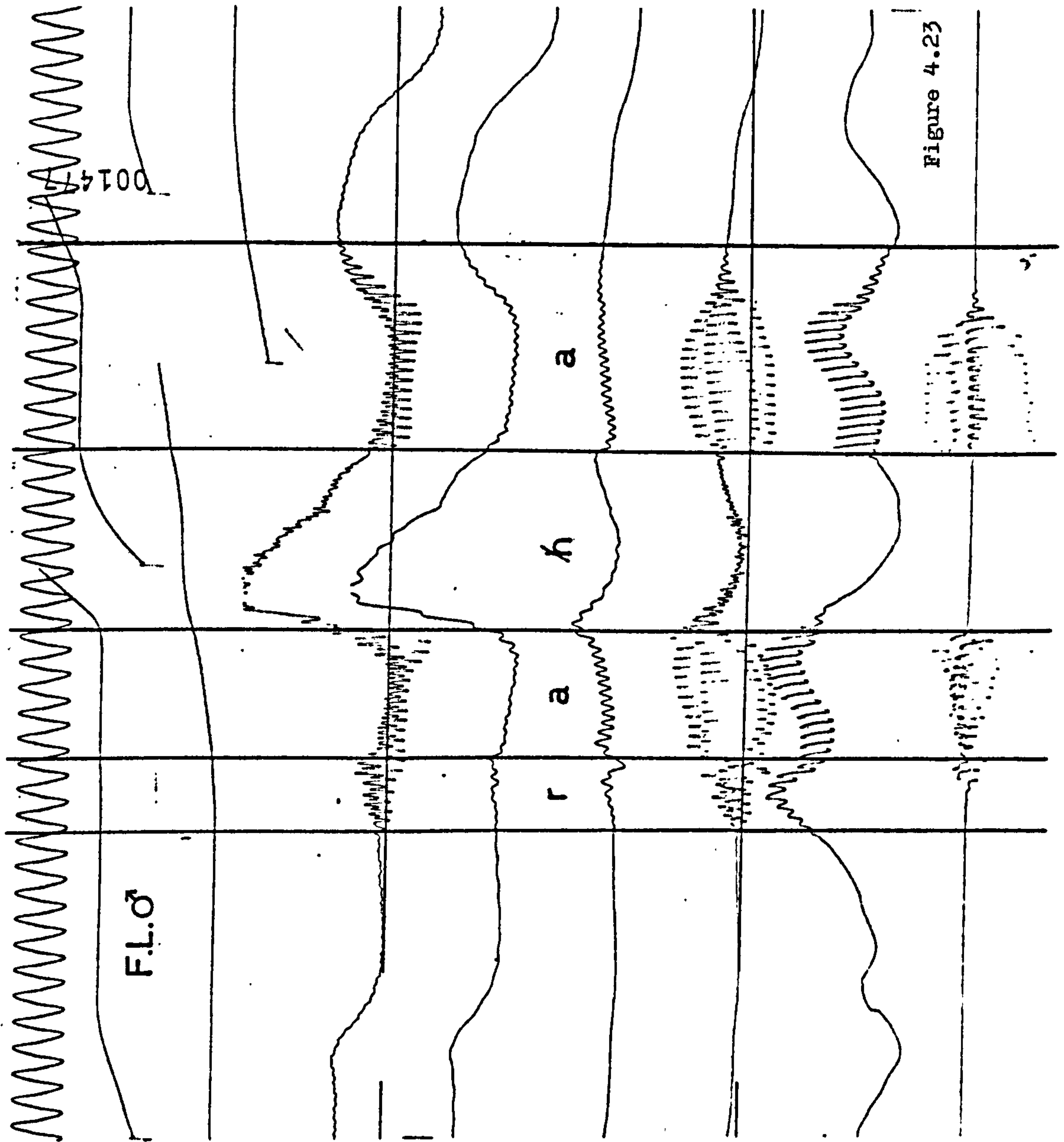


Figure 4.22



nasal airflow is present for the segment /3/ and the adjacent vowels where the average flow rate for /3/ is about 50 ml/s. The vowels here have more oral airflow than /3/, which has a minimum oral airflow.

The pattern of the nasal airflow that was observed for /ŋ/ in Figures 4.21 and 4.23 is evident in other examples with /ŋ/ in an initial position, e.g., in /ŋilim/, Figure 4.25, where /ŋ/ has a maximum airflow through the nose of 200 ml/s, which decreases for the following vowel then increases for /l/, which has an average flow rate similar to the final nasal /m/; the second vowel, /i/, has a slightly more nasal flow than the first one, an influence of the final nasal. Oral airflow for /ŋ/ increases gradually towards the articulation of the following vowel /i/. The total airflow, nasal and oral for /ŋ/ is much larger than any of the other segments.

In /3ilim/, Figure 4.26, the airflow is almost zero at the start of voicing and increases for both nasal and oral with a slightly more nasal airflow. The nasal airflow continues to increase for the following segments.

When /ŋ/ occurs in initial position followed by an open vowel, /a/ in /ŋaDD/, Figure 4.27, there is a maximum airflow through the nose which is 260 ml/s which is similar to that in the medial position. The nasal airflow decreases almost to zero at the start of the vowel. The oral waveform pattern is typical for /ŋ/, which is almost constant

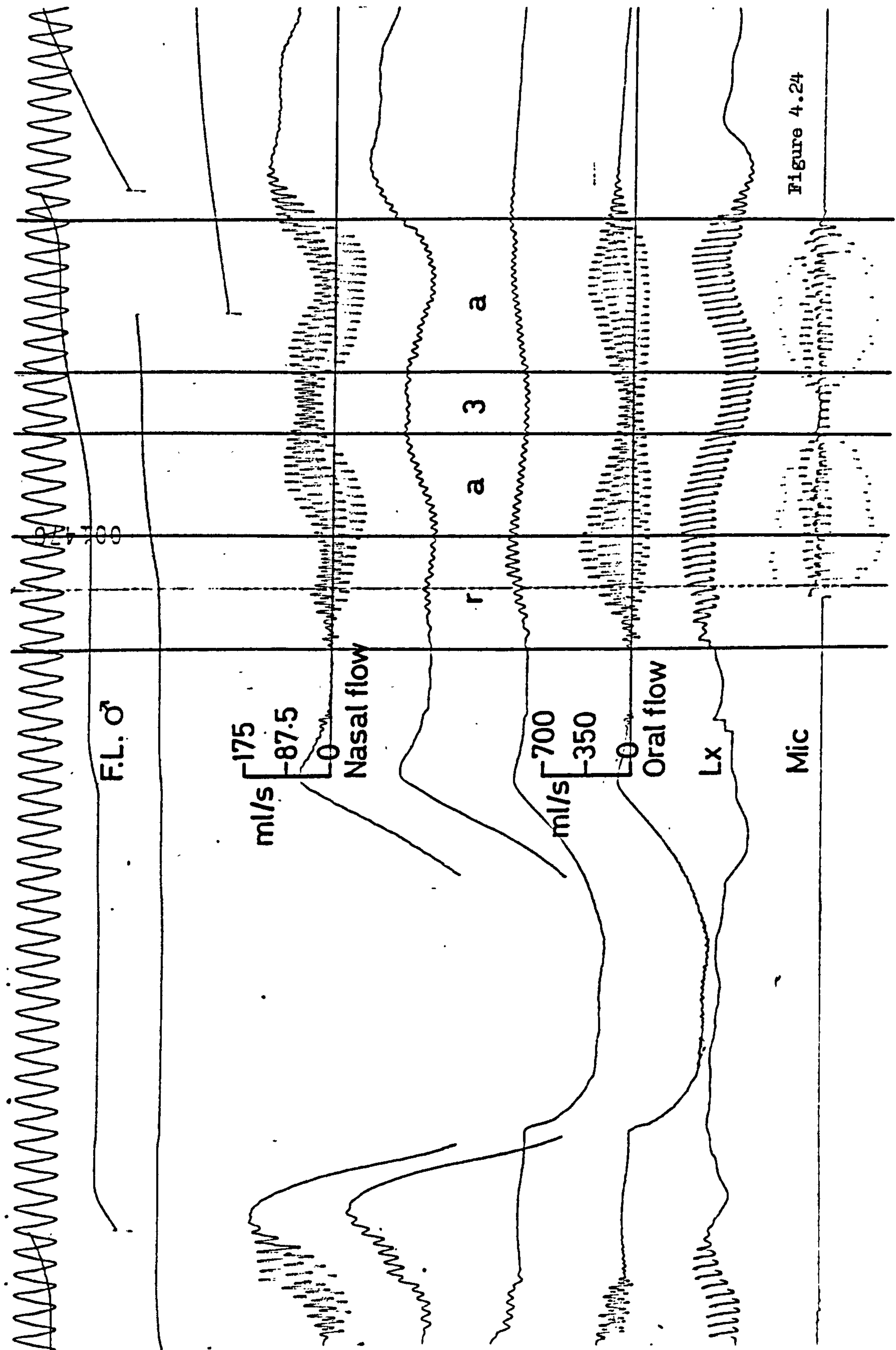
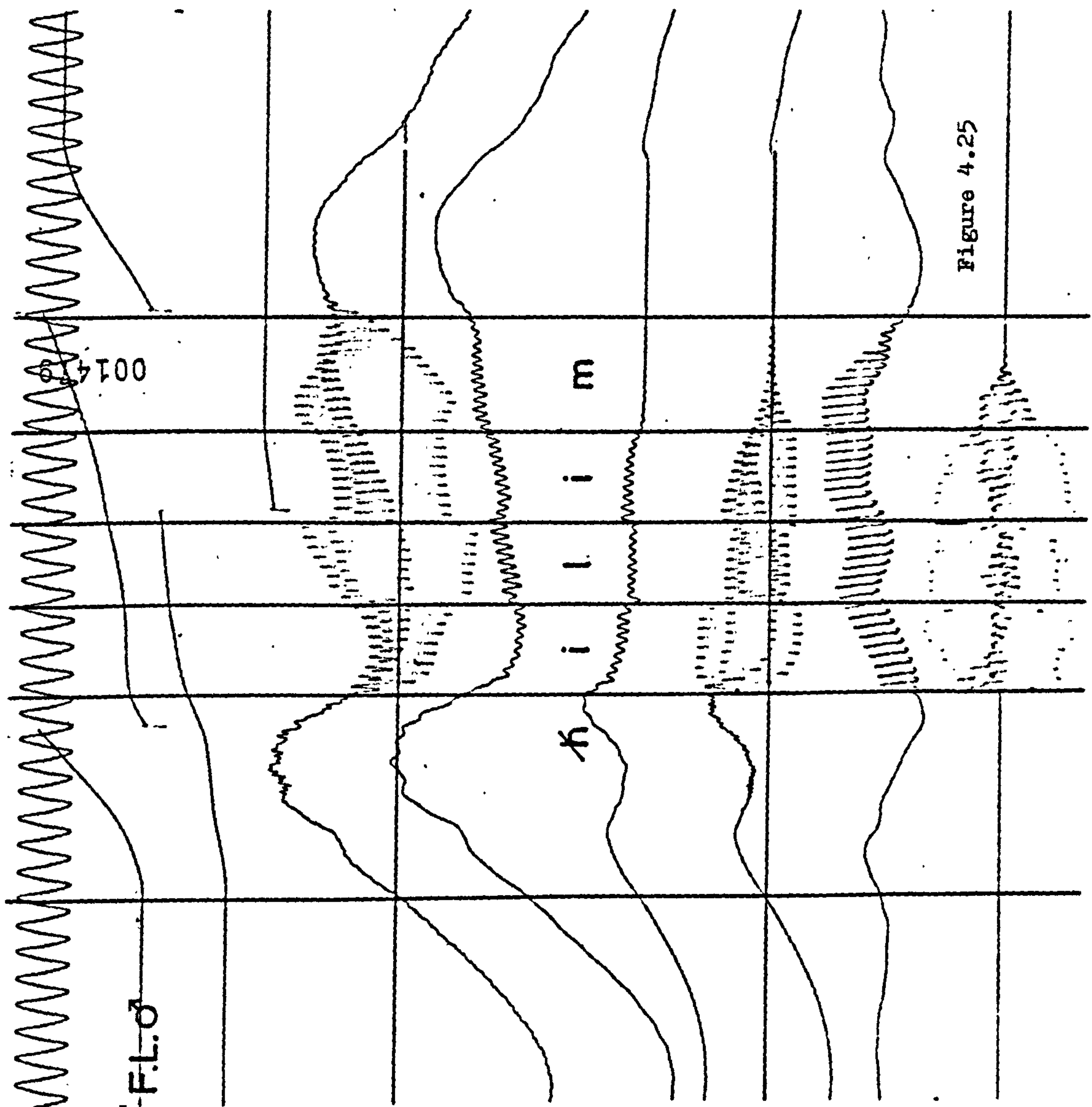
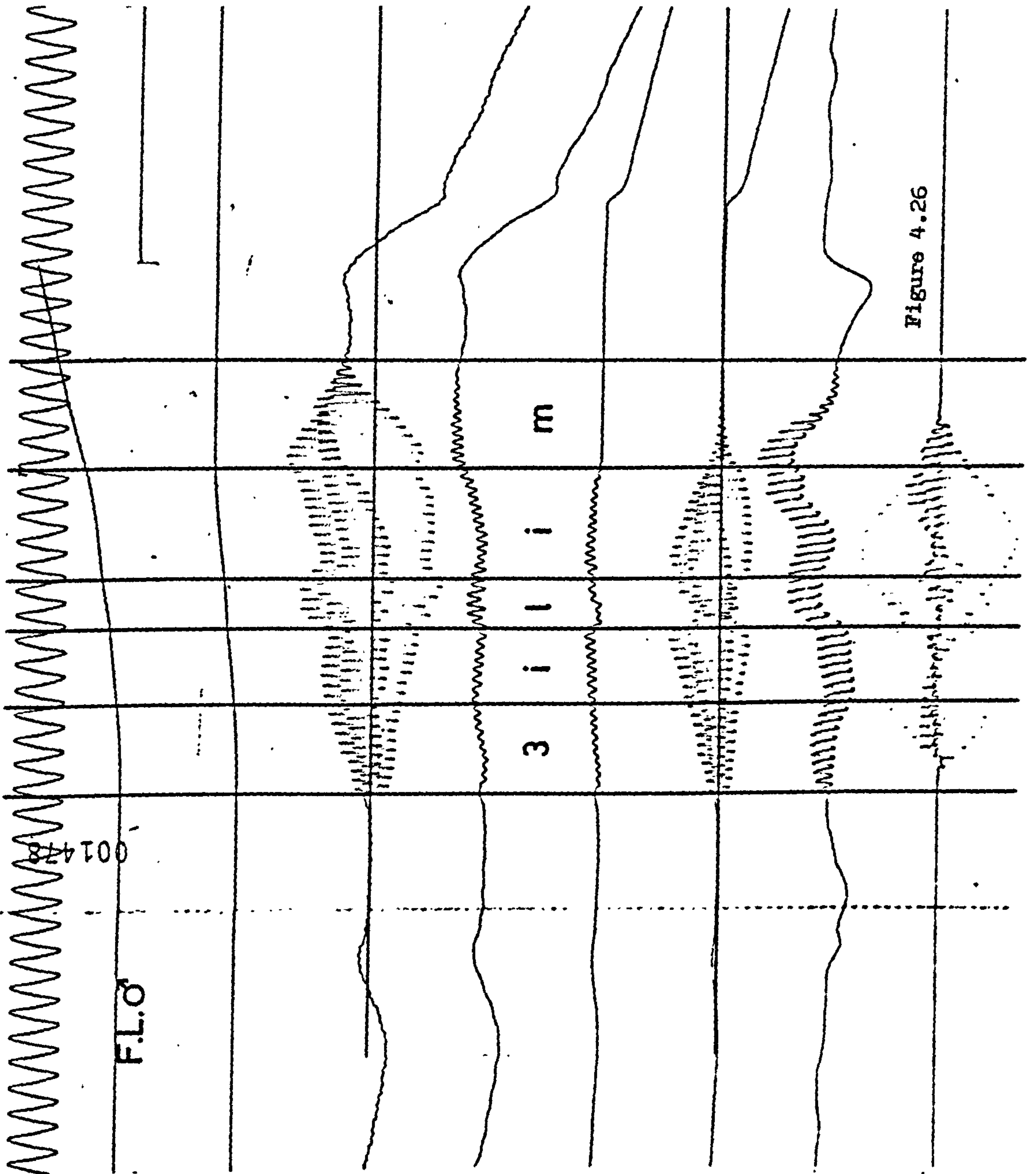
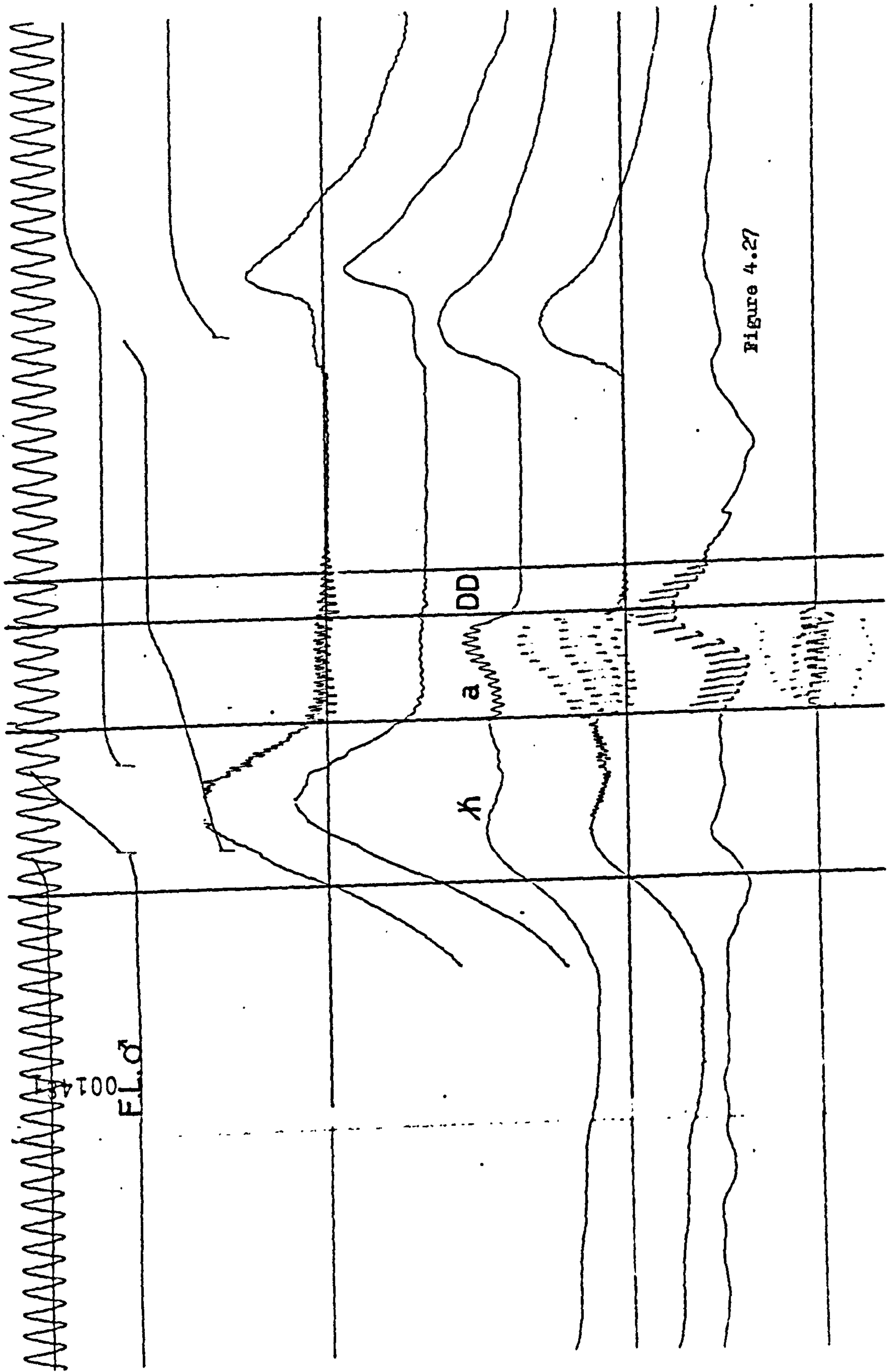


Figure 4.24







throughout the duration of the segment, with a final value of 280 ml/s when voicing starts. For /ʒ/ in /ʒadd/, Figure 4.28, again very similar to that pattern present for /ʒ/ in /ʒilim/, that is, nasal and oral airflow are zero as voicing starts for /ʒ/, followed by a smooth increase in nasal flow rate which occurs before the maximum oral flow rate for the vowel is reached. There is slightly more nasal airflow for /ʒ/ than the oral airflow.

When /ŋ/ occurs in a final position in the word /sama:ŋ/, Figure 4.29, the nasal flow rate for /ŋ/ is greater than that for the nasal sound /m/ with an average flow rate of 148 ml/s. There is an oral airflow of 170 ml/s at the start of /ŋ/, which decreases in the middle of the segment. In /sama:ʒ/, Figure 4.30, there is a slight dip in the pattern of the pharyngeal /ʒ/, the nasal airflow continues until the end of the segment. It is not possible to have a segmentation line between /a:/ and /ʒ/, because the two sounds blend into one another.

Results of airflow analysis of words said by subjects FL and WL of which a few are reproduced in this thesis, indicate that airflow patterns for the pharyngeal consonants /ŋ/ and /ʒ/ are mostly different except in those cases where a) the voiceless pharyngeal /ŋ/ occurs in the context of a nasal sound, and b) where the segment /ŋ/ is

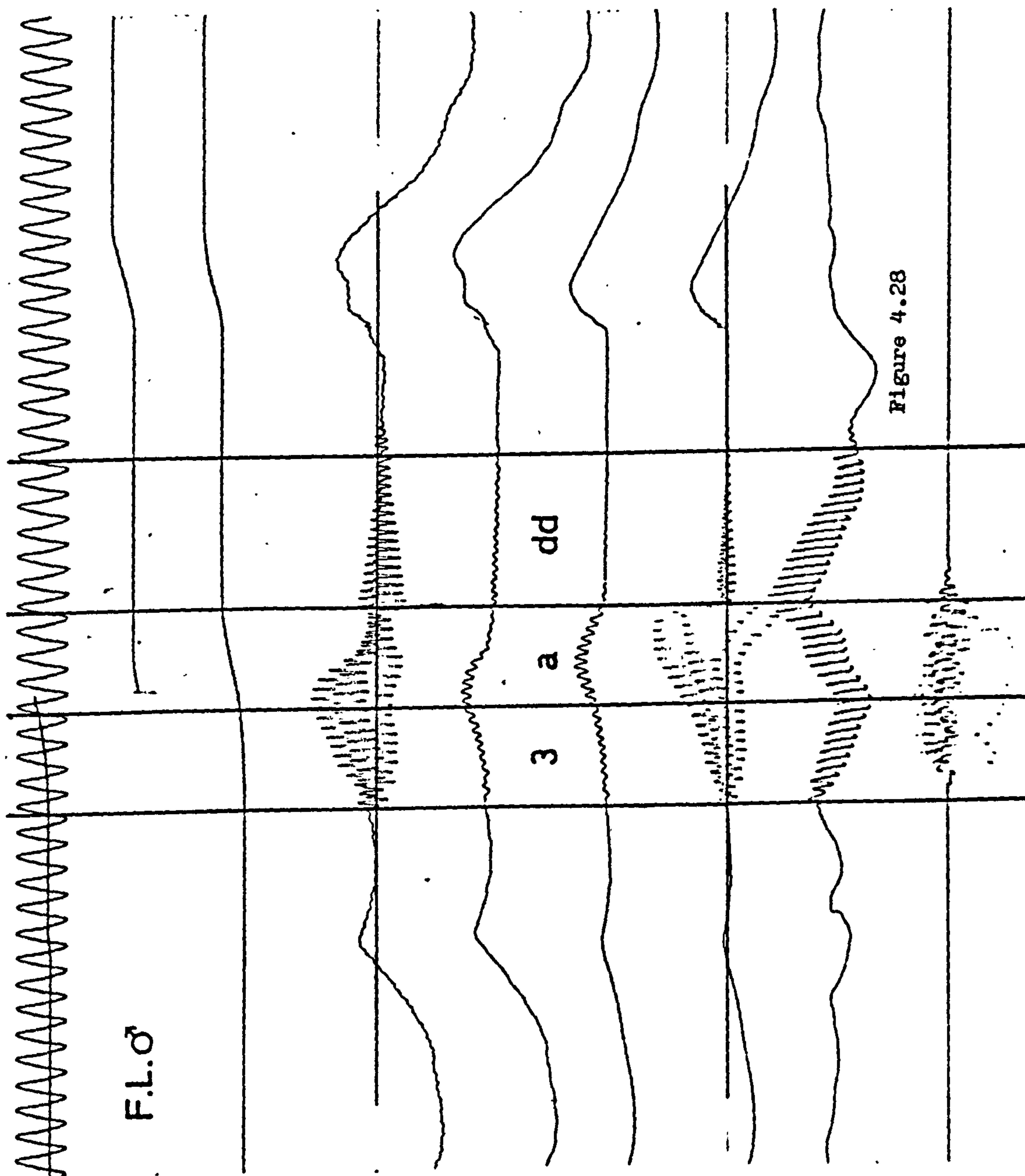
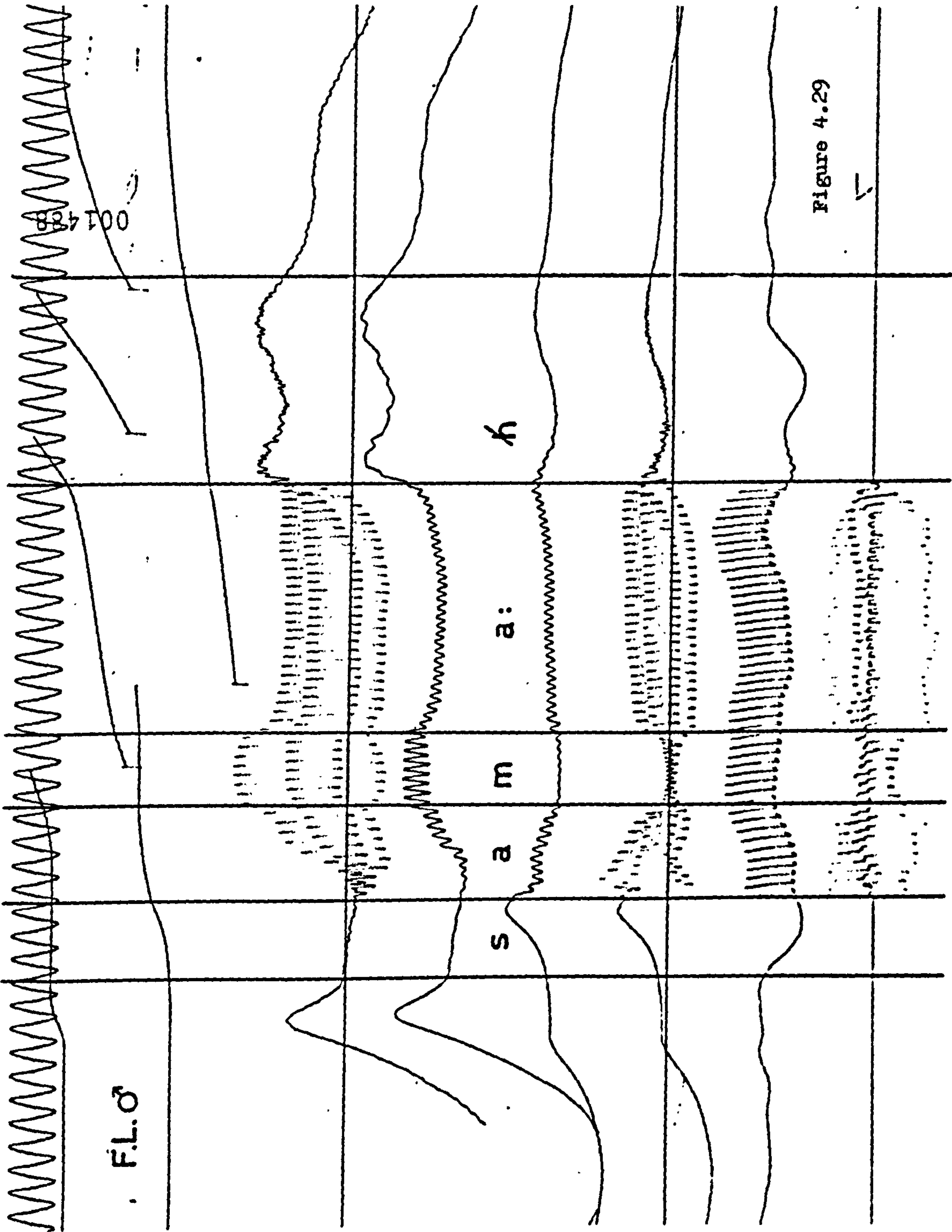
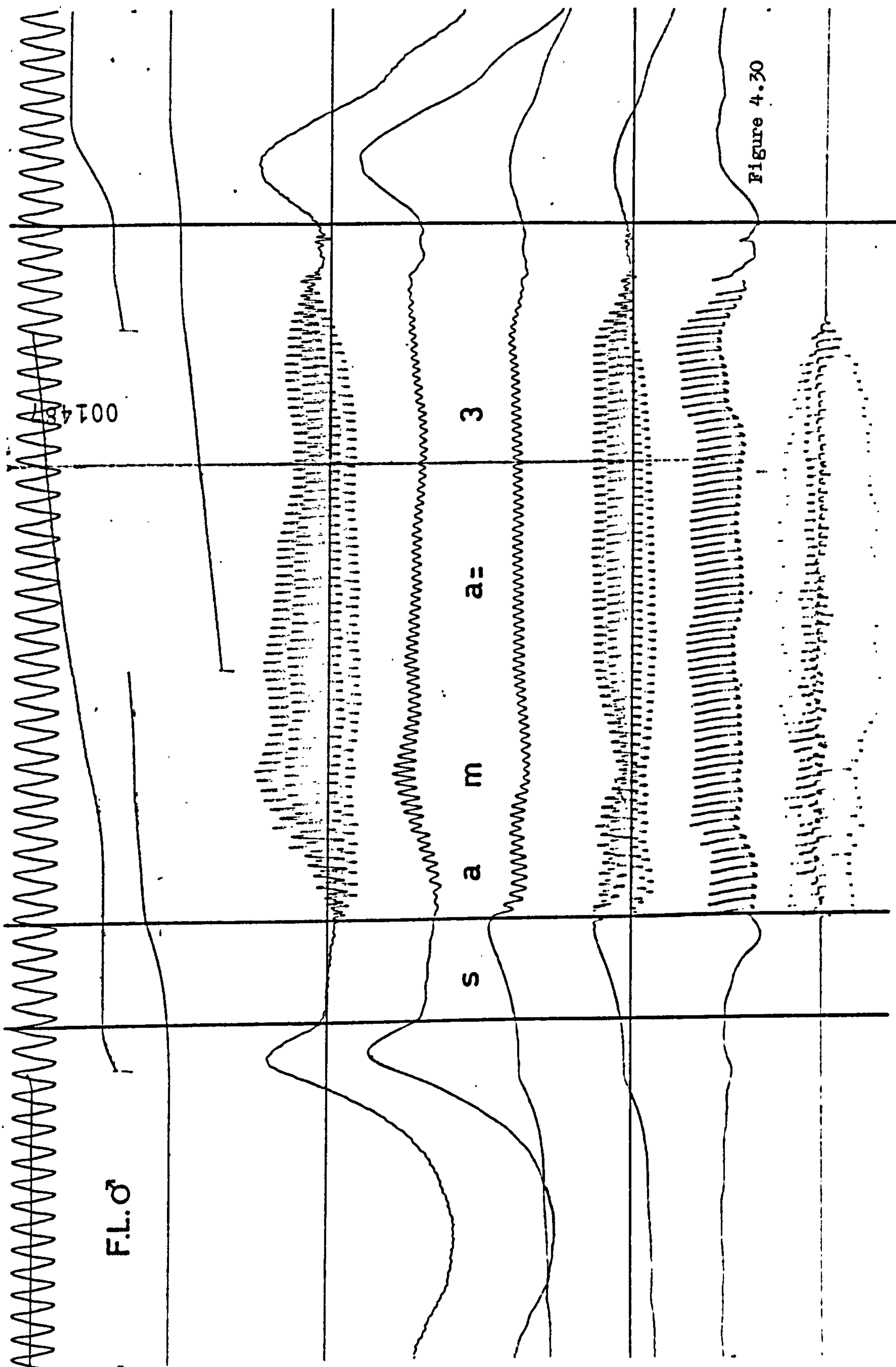


Figure 4.28





in a medial position and geminated in the context of nasal sounds. Subject FL's articulation of the pharyngeal consonants, particularly the voiceless one /ħ/, entails a lowering of the soft palate (videofluorographic and airflow evidence), which results in airflow through the nose. This is the case whether /ħ/ is in an initial, medial or final position; single or geminated and with or without a nasal sound in the context as in the case of /raħa/, and /ħe:T/, Figure 4.31, the average flow rate through the nose for the segment /ħ/ is 148 ml/s in both cases.

The waveshape of the nasal airflow for /ħ/ can take various forms, depending on its position in the word and adjacent segments. If it is initial, then it has a smooth rise and fall, the peak value of flow occurring in the middle and flow falling to zero when a stop follows, otherwise, the peak is at 2/3 duration and the flow decreases during the vowel. If it is medial, whether it is single or geminated, it also has a smooth rise and fall, but the peak is at about 1/3 duration. If it is final, it has a double rise and fall, but it is difficult to determine when /ħ/ actually ceases to be audible as the second peak may have the function of respiration.

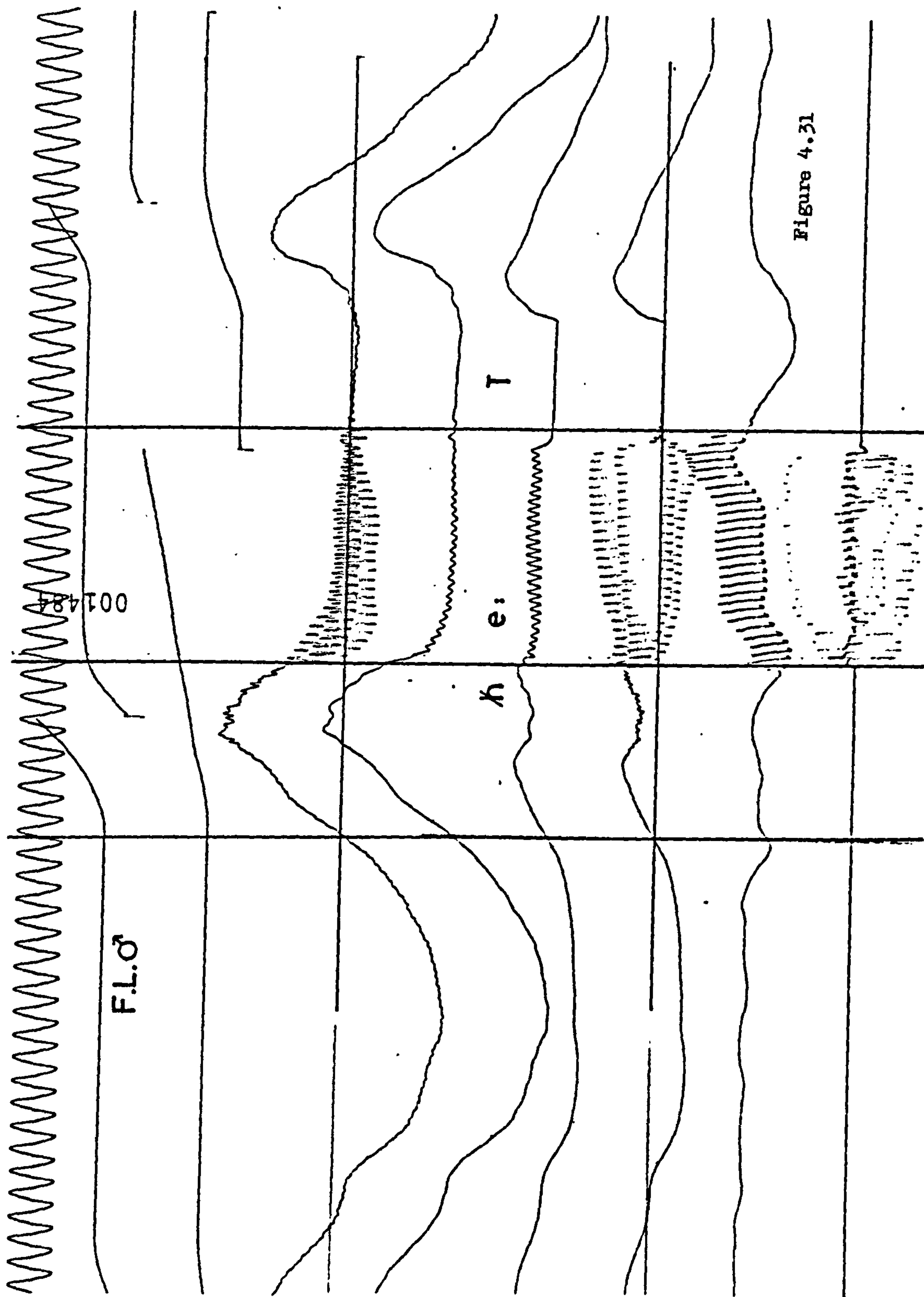


Figure 4.31

To attempt to explain the presence of nasal airflow in these records in relation to other sounds in the context or to the position of the segment in the utterance, airflow through the nose should be expected when /ŋ/ occurs in an initial position because the soft palate, in that case, retains its 'at rest' (inspiratory) position through the articulation of /ŋ/. The same expectation lies behind the presence of nasal flow when /ŋ/ is in a final position where the soft palate starts lowering during the production of the vowel in anticipation of the /ŋ/, and to take up once again, the 'at rest' position, which is then maintained through the period of the end expiratory volume and through the inspiration following, (Anthony, 1982).

Some airflow through the nose can be seen to occur in the words /waŋŋada/ and /maŋŋana/, as said by WL, Figures 4.32 and 4.33, respectively. This, however, is not of a significant level except in those cases where a nasal sound is in the context, that is, where airflow through the nose for /ŋ/ is maximum. In medial position whether /ŋ/ is geminated or non-geminated with the consonants /b/, /k/, /g/, /s/ and /ʃ/ in initial position and in the word /aŋŋa/, nasal airflow is reduced to zero.

This difference in the pattern of nasal flow rate between the articulation of /ŋ/ of the two subjects who

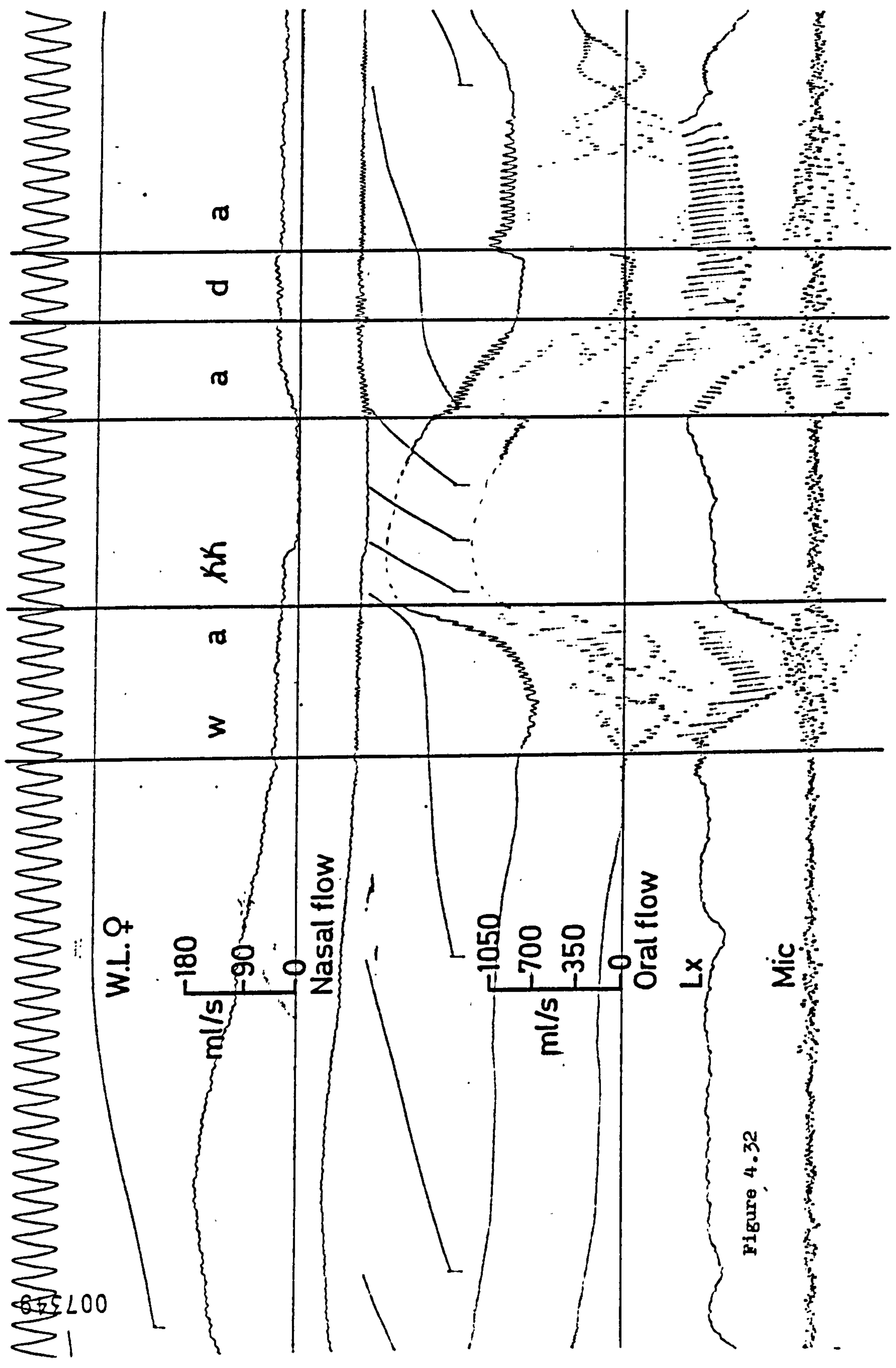


Figure 4.32

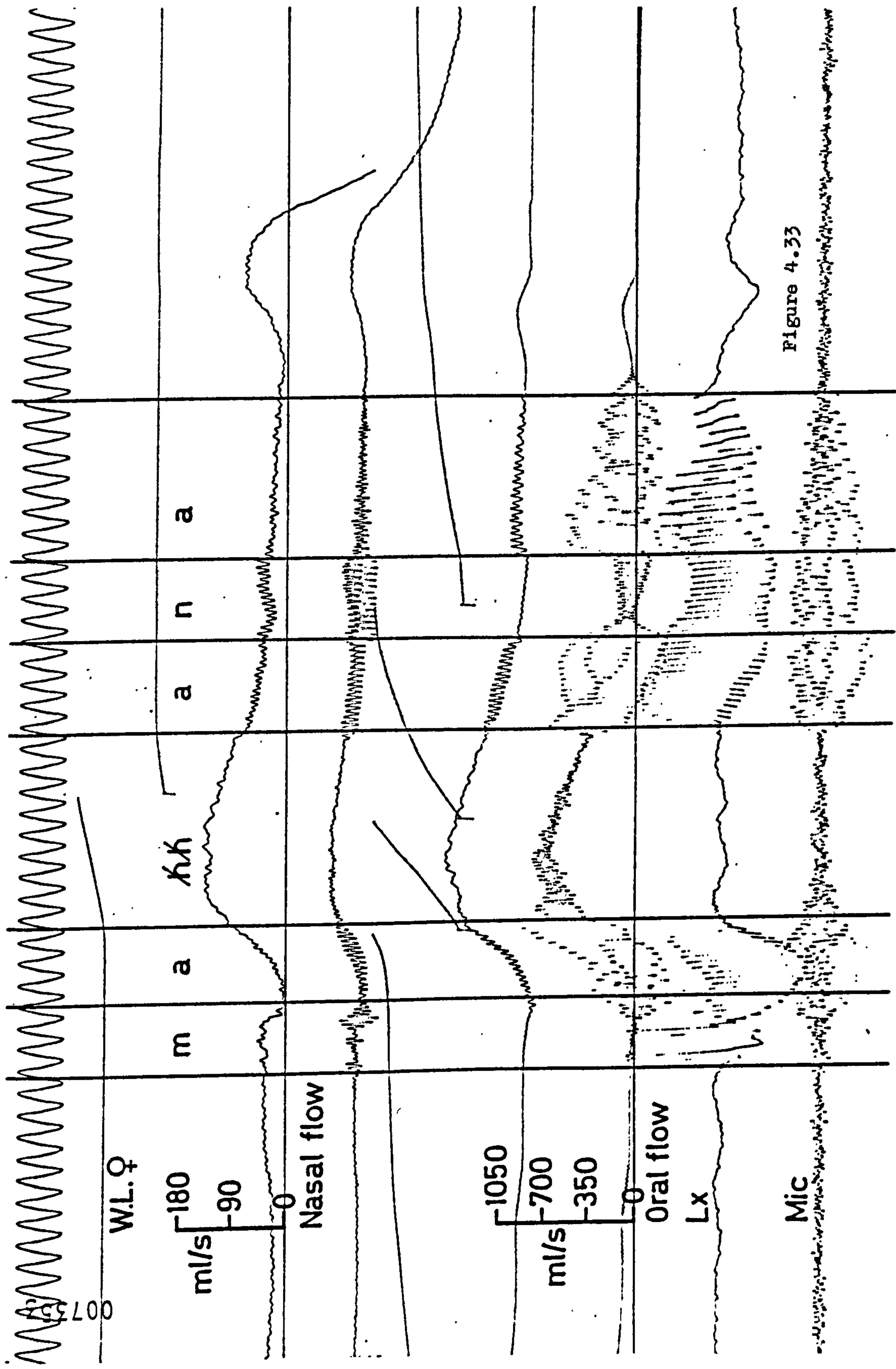


Figure 4.33

speaking the same dialect and come from the same family may be due, of course, to many reasons, and a conclusion cannot be drawn from two examples, but it would be reasonable to put forward a female/male difference of production, although one is inclined to believe that the articulation of the pharyngeal consonants, especially /ħ/, is characterized by a lowering of the soft palate, the degree of which varies from one individual to another. This conclusion is reasonable on the basis of the low place of articulation for these sounds where the palatoglossus muscle pulls the tongue root and the velum down because the tongue and the velum are connected to each other by this muscle.

CHAPTER V

The Uvular Consonants

The classification of the consonants /X/, /g/ and /q/ as uvulars is quite recent. Early Arab grammarians like Sibawaih, Ibn Jinni and Al-Khalil, classified the fricatives /X/ and /g/ as pharyngeals with /h/, /ʔ/, /ħ/ and /ʕ/. They described /X/ and /g/ as having a higher place of articulation in the pharynx "at the beginning of the mouth". Modern Arab grammarians also classify /X/ and /g/ as pharyngeals, probably influenced by the early Arab grammarians, who included the voiceless uvular stop /q/ with /X/ and /g/ and described it as having a more fronted position in the palate than /X/ and /g/. This led some modern Arab linguists to speculate that the old pronunciation of /q/ was not what is used at the present time by educated Arab speakers, but somewhat similar to the sound heard in the Sudan and the South of Iraq, that is, a somewhat retracted voiced velar stop. Anis (1961), points out that this may be the reason behind the use of /g/ by, for instance, speakers of the western Arabic dialects as a result of the settling of the Arabs of Hijaz in the 5th Century of Hijra. Later, /g/ lost voicing and became the /q/ that is used today by the educated speakers of Arabic. Though the above explanation is plausible in the case of the other North African dialects, one is sceptical

in view of the fact that /q/ in TA is only used in words from the Koran or loan words from Classical Arabic.

In TA, /q/ occurs only in loan words from Classical Arabic where /g/ cannot be substituted. Nevertheless, even in those cases where lectures or speeches are given, the use of /q/ instead of /g/ is governed by the individual's background, /g/, however, is replaced by /q/ mainly in slow careful speech. It seems that there are cases where /g/ is readily replaced by /q/, for example, where /g/ instead of /q/ would render a different meaning, for example, /rigga/ 'thinness' in shape or size, and /riqqa/ 'delicacy' from delicate thing or person. In other cases, the use of /g/ in words like /qawmiyya/ 'nationalism' would be looked down upon. An educated speaker would never replace /q/ by /g/ in this position. The same applies to other words, e.g., /qurʔa:n/ 'Koran', /*niqma/ 'vengeance'. It is interesting to note that /g/ cannot be substituted for /q/ in this position to have /nigma/. The hearer would immediately think of /nigma/ as the Egyptian Arabic word for 'star' and would naturally be surprised at its appearance in the given context. Nevertheless, a very frequent use of /q/ in words which are generally used in colloquial with /g/ would categorise the speaker as a learned religious person and the occasion as formal.

Among European scholars, Delattre (1971), for example, groups /q/, /X/ and /R/* with the pharyngeals /ħ/ and /ʕ/.

* As pronounced by most TA speakers.

* R = g

Jakobson (1973), on the other hand, groups them with the pharyngealized consonants, and the voiceless velar stop /k/ ˀ under 'mufaXXama'. Ali and Daniloff (1972), group /q/ with the pharyngealized consonants /ṭ/, /ḡ/ and /s/ under 'emphatics'; they consider /k/ the non-pharyngealized counterpart of /ḡ/, /ḡ/ being pharyngealized. This, as will appear later, is not consistent with the characteristics of a pharyngealized consonant where two places of articulation are involved, a primary one with tip or blade of tongue and a secondary one with root of tongue retracted in the pharynx. The first feature is not present in /q/. Only one articulation appears which is that of the retraction and raising of the dorsum of the tongue until it touches the soft palate for a complete closure to produce a stop.

This grouping of the uvular consonants with the pharyngeals or the pharyngealized is largely due to the classification of the early Arab grammarians of the consonants under 'mustaʕliya' and 'mufaXXama'. They, however, related '?istiʕla?' to articulatory features, while 'tafXiim' was reserved for auditory or acoustic features. 'tafXi:m' applies to all the 'mustaʕliya' sounds as well as the 'muTbaqa' or pharyngealized sounds, (Ghazeli, 1977).

As mentioned, the confusion in the classification of all the consonants made in the pharynx undoubtedly arises from the similarities of their articulatory features. All of them are made in the pharynx irrespective

of the place of the articulation in the pharynx. The uvulars: either a complete closure with the soft palate or a constriction is necessary for the production of /q/, /X/ and /g/. Being somewhat closer for /X/ than for /g/, that is, the tongue assumes a little higher position in the mouth for /X/, than it does for /g/.

The confusion also stems from the influence of retraction of these sounds on the adjacent sounds, though this is only true in certain cases. Shaheen (1979), in his acoustic study of the sounds of Egyptian Arabic, found that /X/ and /g̤/ exert negative transitional influence on all the front vowels; /g̤/ exerts negative influence on all the vowels, whether they are front or back. They mainly exert positive transitional influence on the position of the second formants of the adjacent back vowels. However, Ghazeli (1977), found that F1 of /ɤ/ is slightly lowered next to /i/ and /u/ , and F2 is slightly lowered next to /u/ and raised next to /i/ .

Dechicha (1980), found that in the Arabic dialect of Algiers, the vowels /i/, /u/ and /ə/ become [e] , [o] and [ʌ₊] respectively next to uvulars. However, /a/ is not backed but fronted and realized as [a_ɪ] .

Ghazeli (1977), found that coarticulatory effect of uvulars is observed only with low front vowels. He found that for all his subjects, the values of F2 of the low vowels next to uvulars are higher than its values next to the pharyngealized consonants. He also found that if the low vowel is front /ɛ/ or /æ/ , then F2 is lowered and F1 is raised. If the low vowel is central, as in the case of the Iraqi and Jordanian subjects then only F2 is lowered. Ghazeli attributes the retraction of low vowels next to uvulars to assimilation, that is, "in shifting from a uvular to [a] , the only tongue movement required is the release of the closure or stricture, that is, the lowering of the back of the tongue. Furthermore, since there are no apparent phonemic contrasts between low front and low back vowels next to uvulars, the extra mechanical demand on the tongue toward displacement of the tongue mass can be spared without affecting meaning".

In the next two sections, X-ray analysis (static, xeroradiographic and video-fluorographic) is given first, followed by endoscopic observation and the analysis of airflow recordings.

5.1 The uvular /q/ See Appendix I for tables of results.

Static X-ray analysis:

The X-ray tracing, Figure 5.1, for the subject (JS) of the voiceless uvular stop /q/ of the word /ba:q/, shows two striking features: a) a very small oropharyngeal cavity and b) a large laryngopharyngeal cavity, much larger than that found at rest. The small oropharyngeal cavity results from the constriction formed by the root of the tongue approaching the back wall of the pharynx and which extends from the level of the epiglottis and C2 to the place of closure high up in the pharynx. The oral closure is made between the top part of the root of the tongue and the uvula, and the soft palate against the back wall of the nasopharynx closes the velopharyngeal orifice. The rest of the tongue from the point of closure to the front, lies along the floor of the mouth in a somewhat concave shape. The hyoid bone is slightly raised with the lateral horns pointing towards the level of C2 at an angle of about 15°.

Xeroradiographic analysis:

The lateral xeroradiogram of /q/ in the word /riqqa/, Figure 5.2 for the subject (WL) exhibits almost identical results to that of the X-ray tracing of the word /'ba:q/,

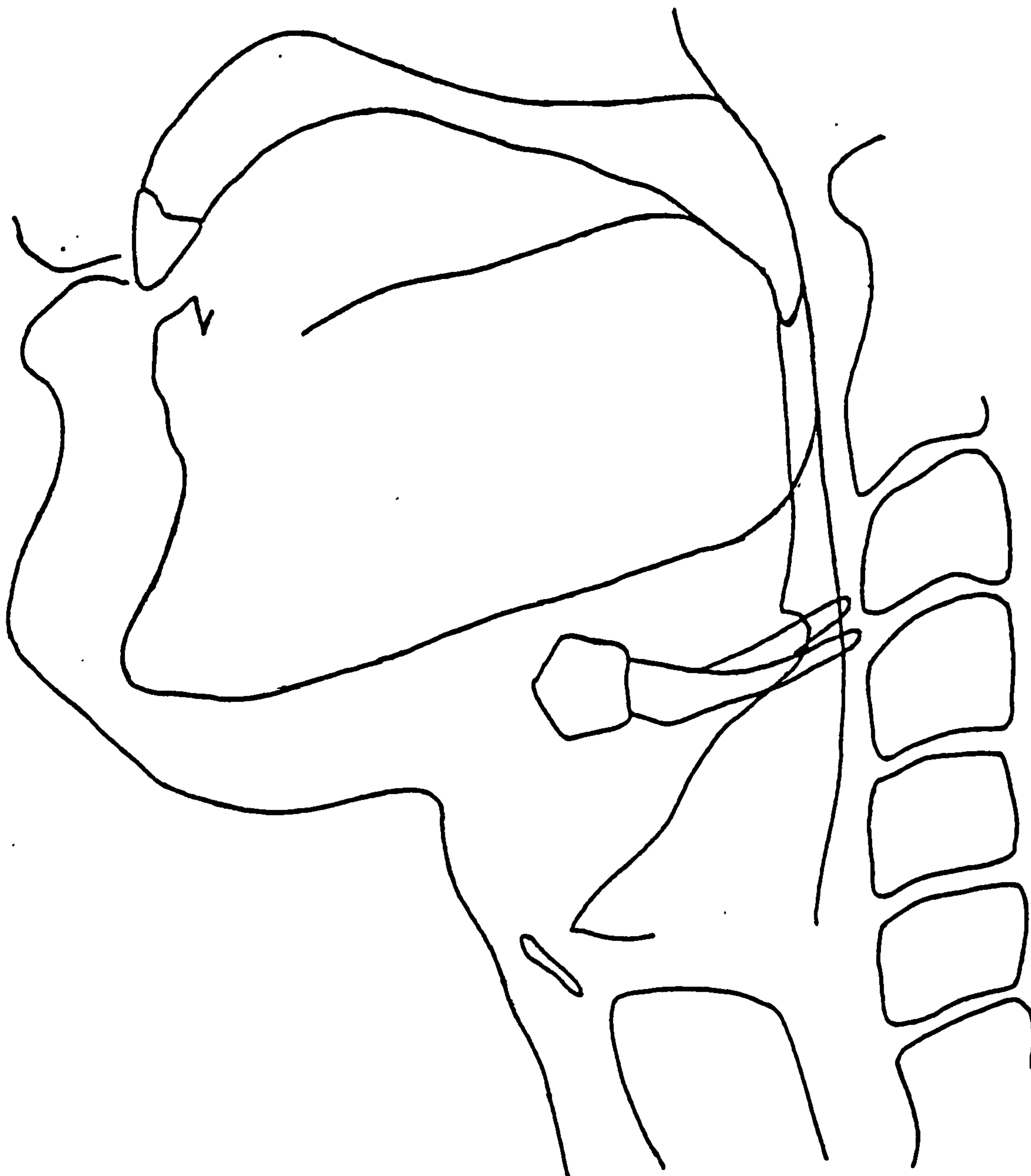


Figure 5.1: /q/ in /ba:q/ (JS)

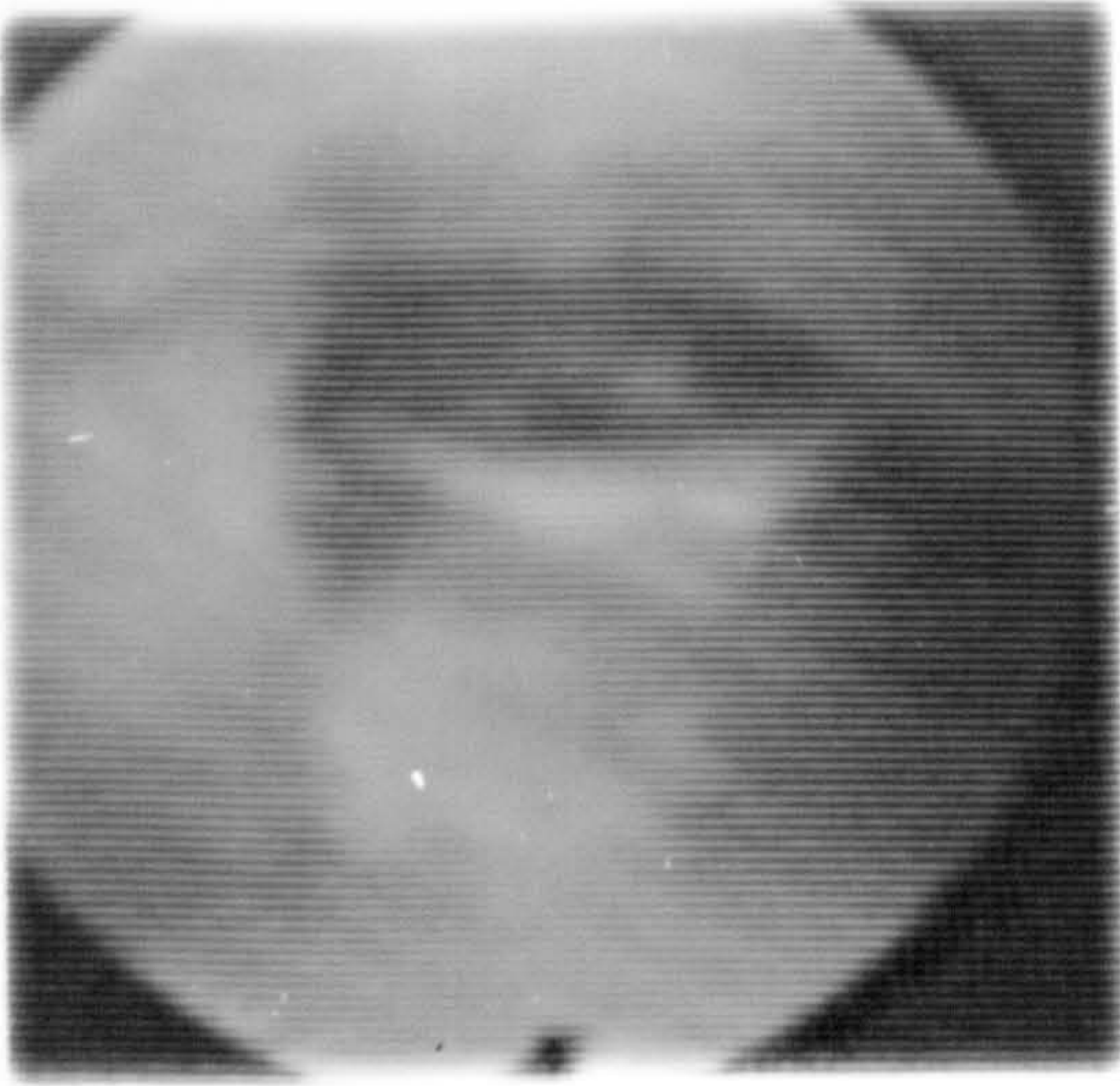


Figure 5.2 /qq/ in /riqqa/. (WL).

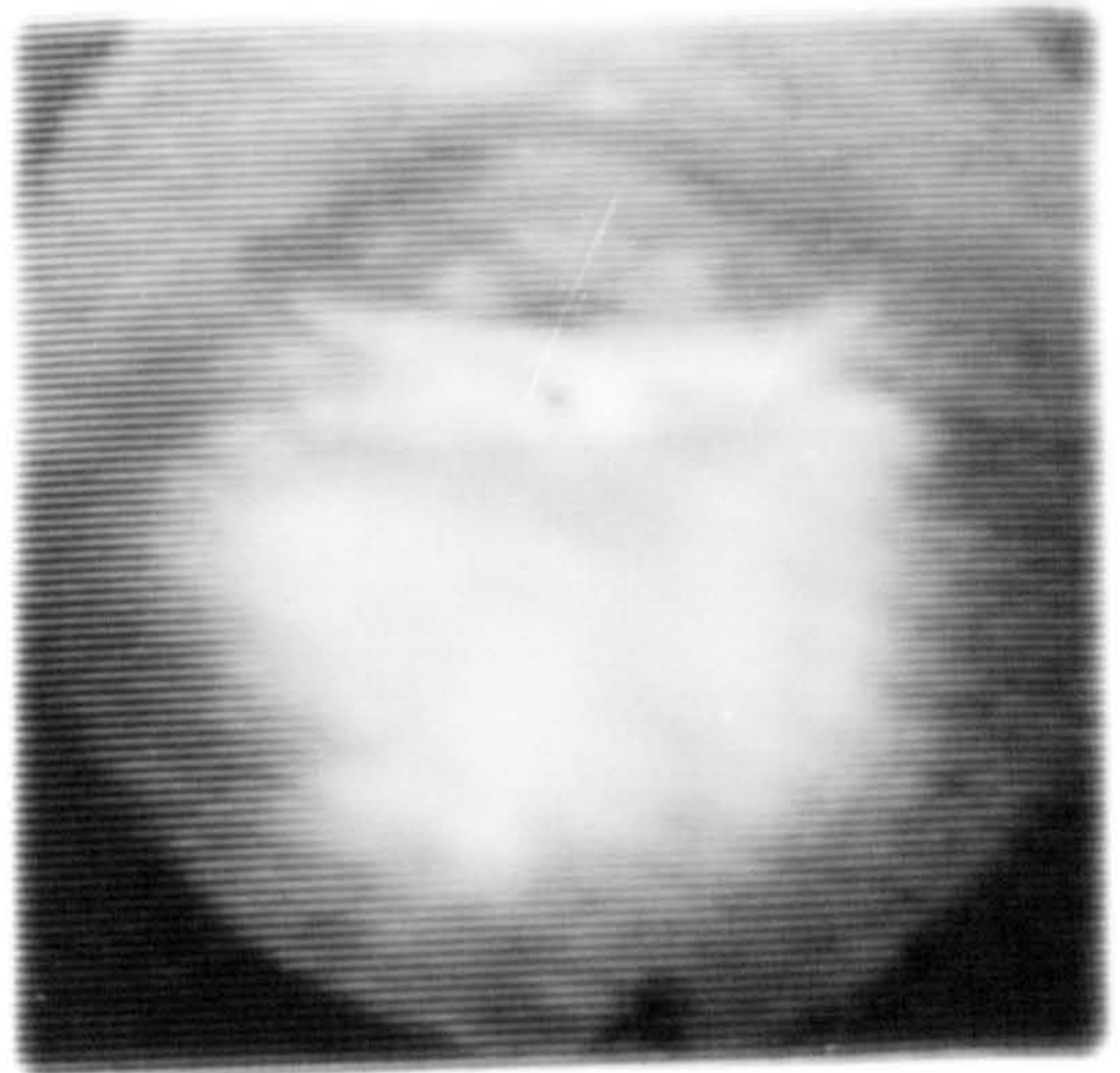
Figure 5.1. The word /riqqa/ was chosen because gemination of /q/ lengthens the period of closure, thus ensuring a higher chance of success in obtaining an exposure at the closure instant. The exposure was taken before the release by personal recollection, and the X-ray itself is good proof of this.

This xeroradiogram of /qq/ in /riqqa/ shows that the constriction extends upwards from the level of C2 to the point of the closure between the root of the tongue and the uvula. The soft palate is in close contact with the back wall of the pharynx (and there is some indication of a Passavants ridge); the tongue has moved back and up and the dorsum makes contact with almost the whole length of the underside of the soft palate. In both pictures, the constriction is similar, starting low down at the level of the epiglottis and extending upwards to the superior end of the pharynx.

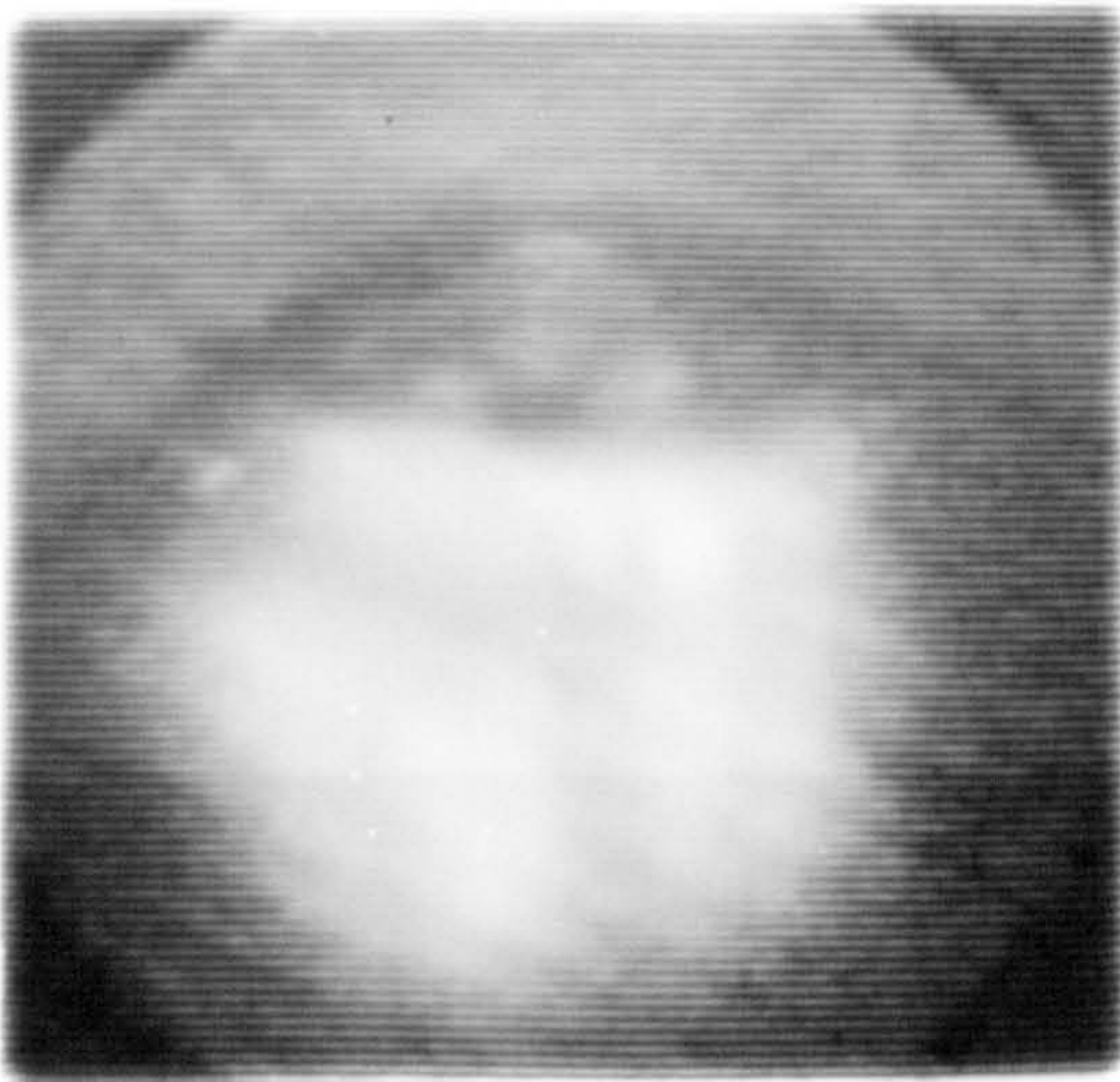
For /qq/, the epiglottis assumes a very similar configuration to that for a pharyngealized sound, although the distance between the epiglottis and the back wall of the pharynx differs, being smaller for /qq/, than for the pharyngealized sounds. The similarity arises mostly from the almost upright shape of the tip of the epiglottis in both cases. In the 'at rest' position and in the production of the other sounds, the tip of the epiglottis curls forward.



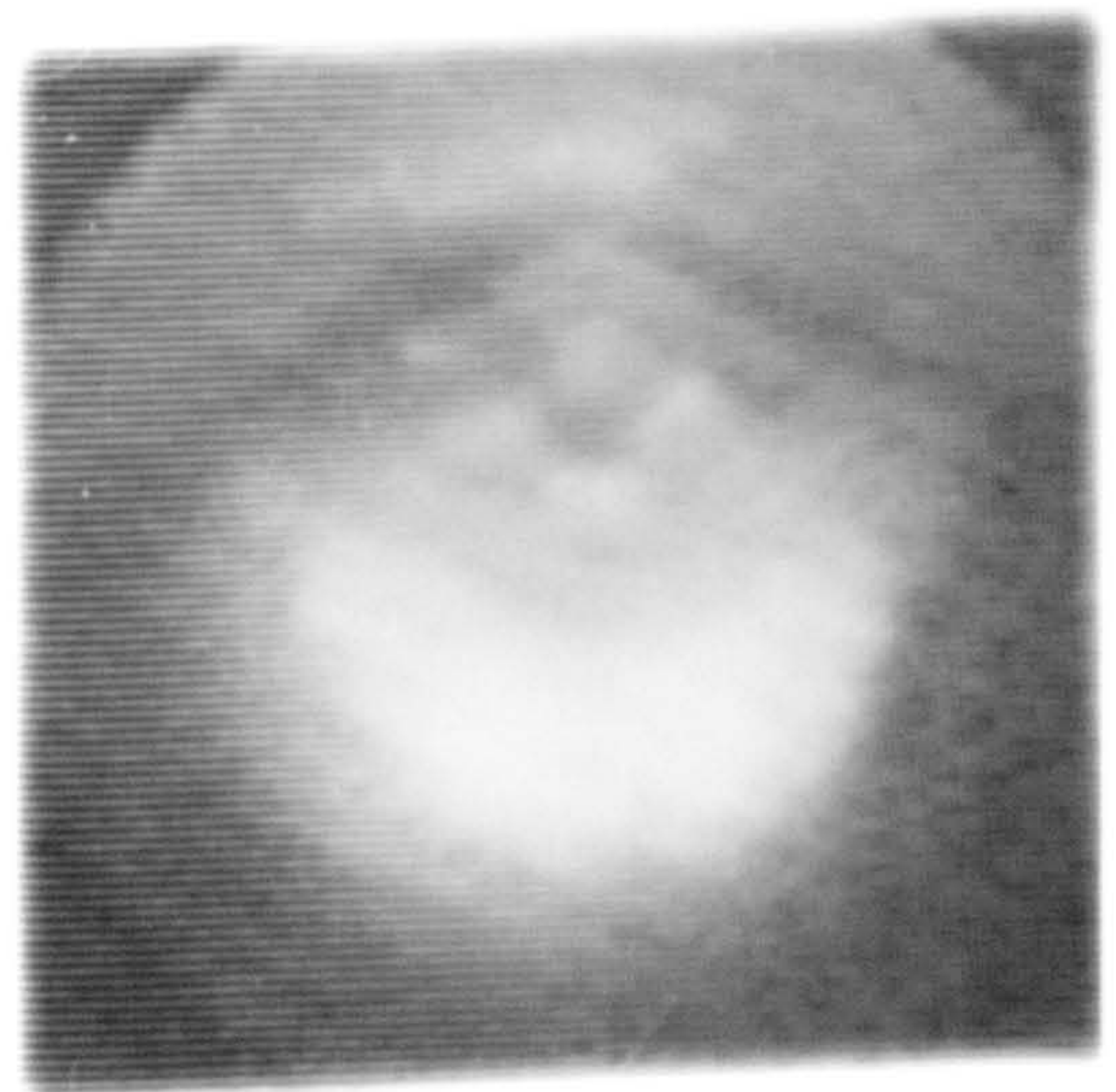
a. medial /q/ in /raqi:q/ (FL)



b. final /q/ in /raqi:q/ (FL)

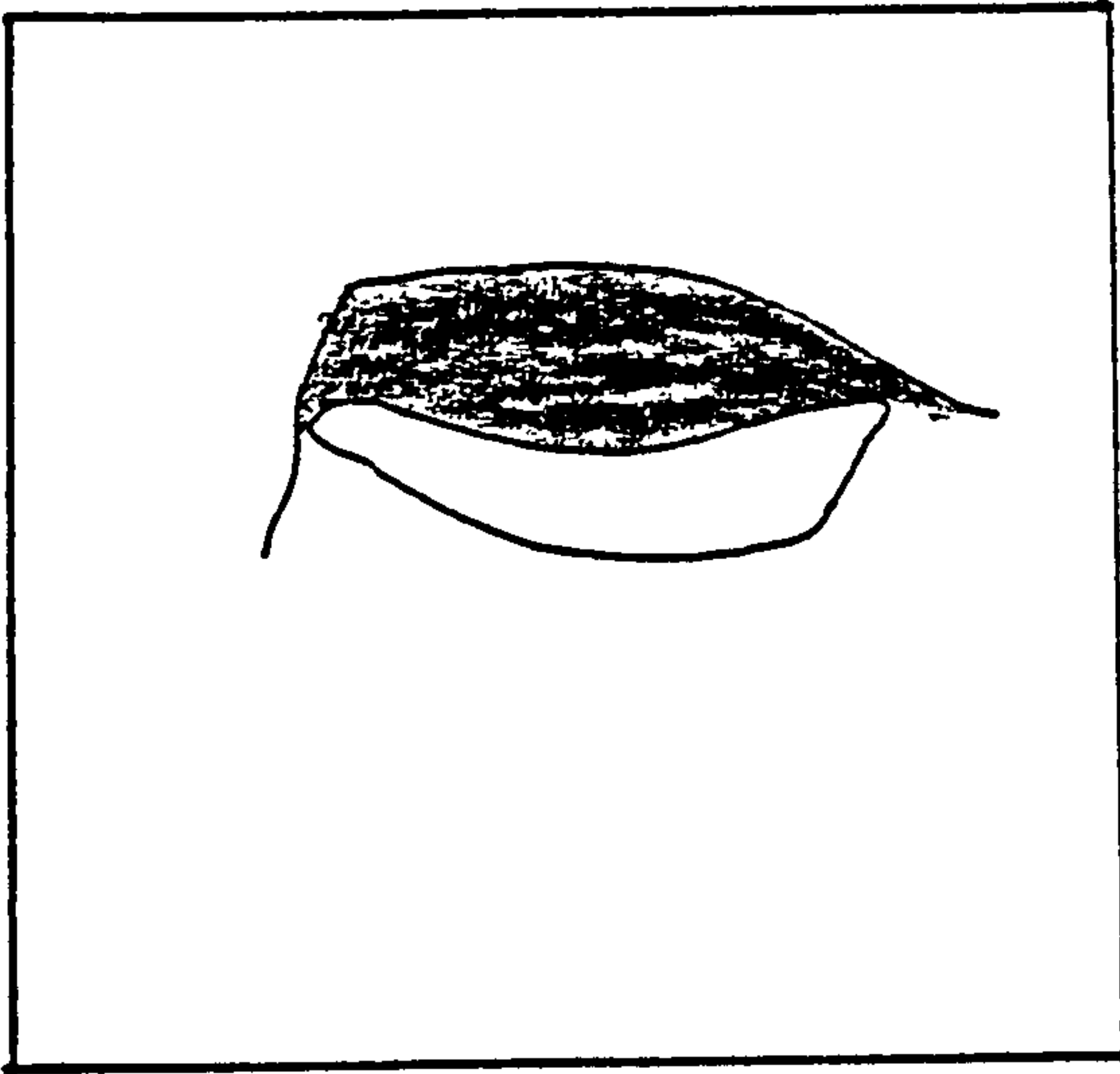


c. /a/ in /raqi:q/ (FL)

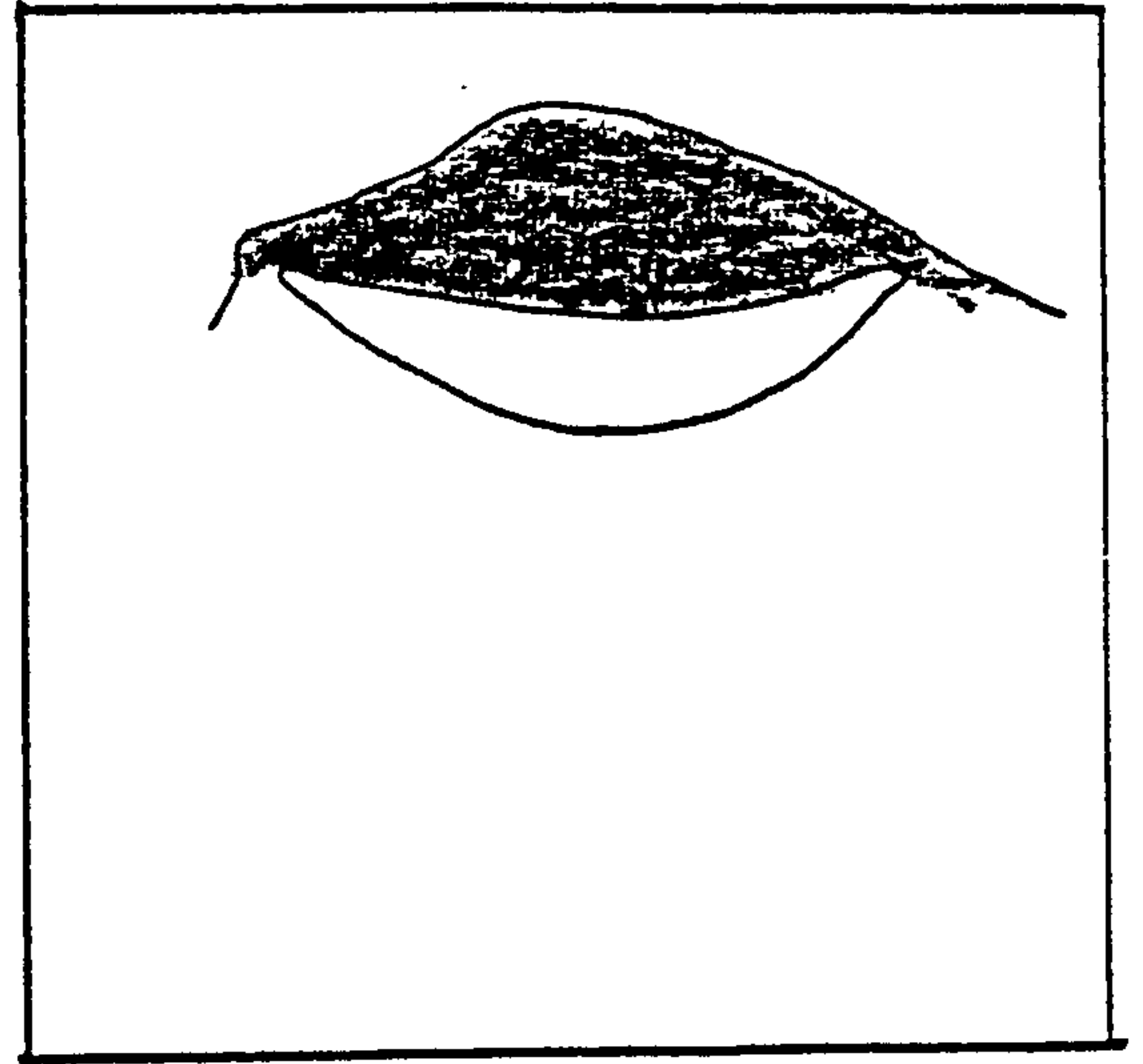


d. /i:/ in /raqi:q/ (FL)

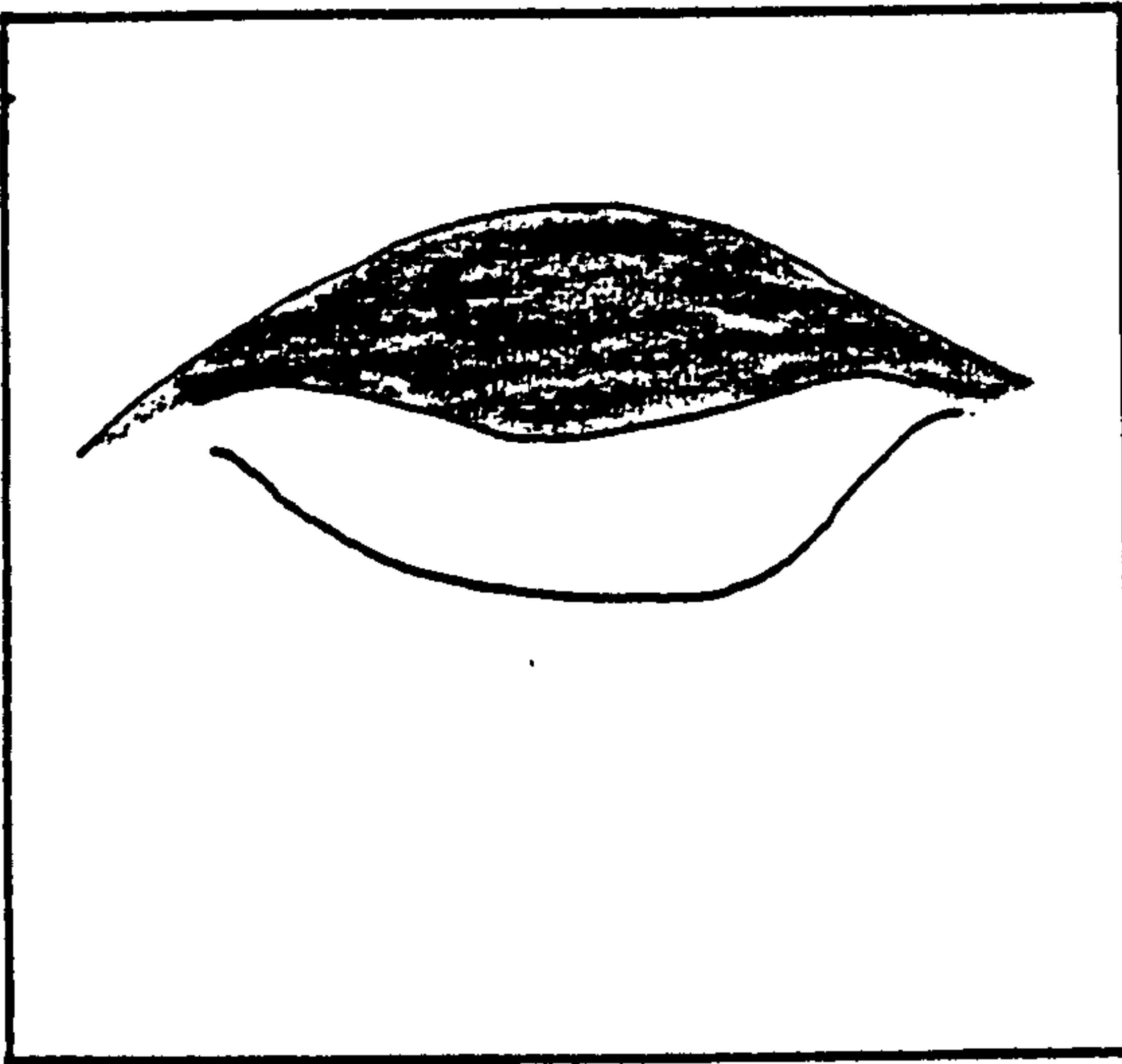
Figure 5.3



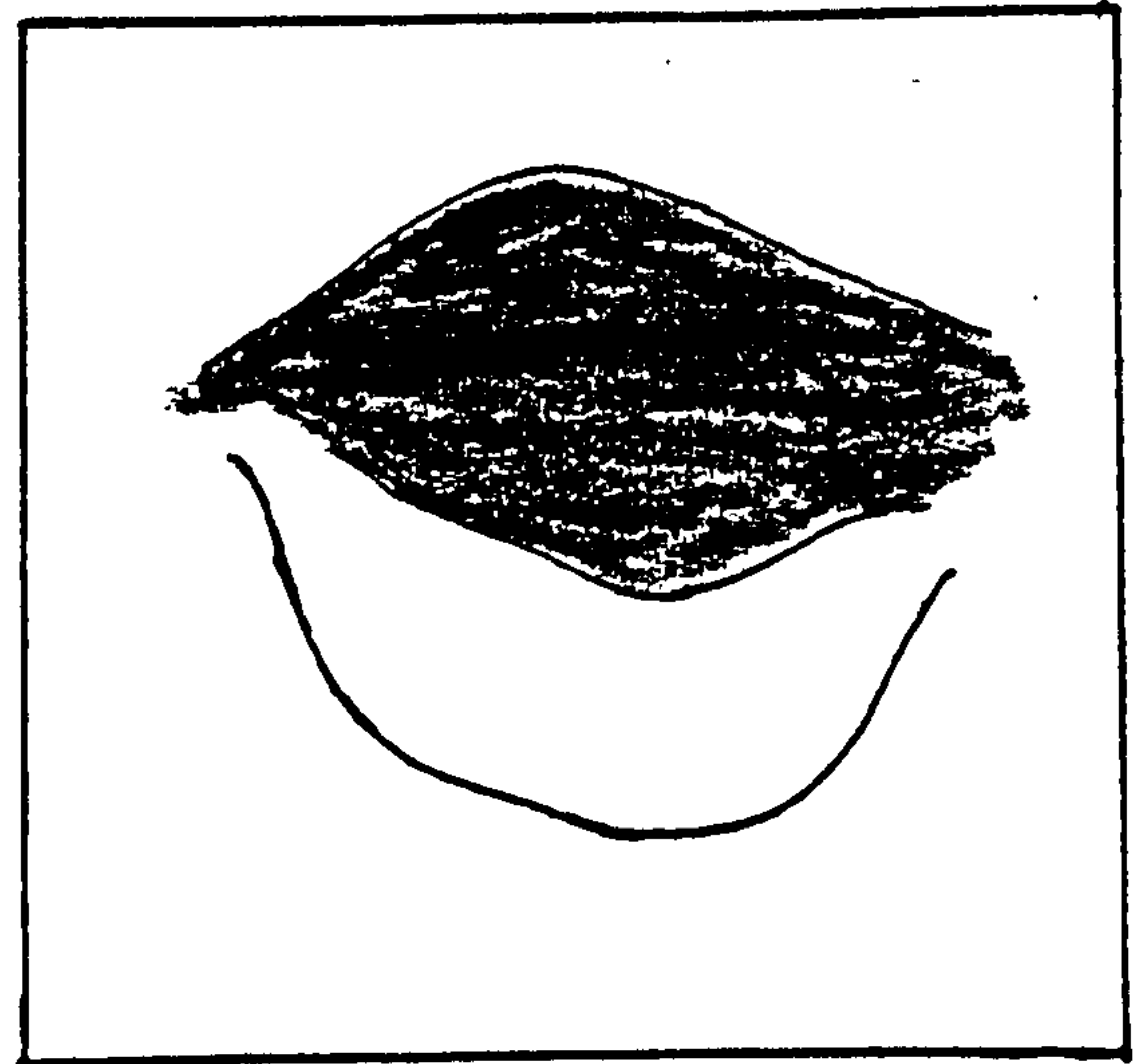
a.



b.

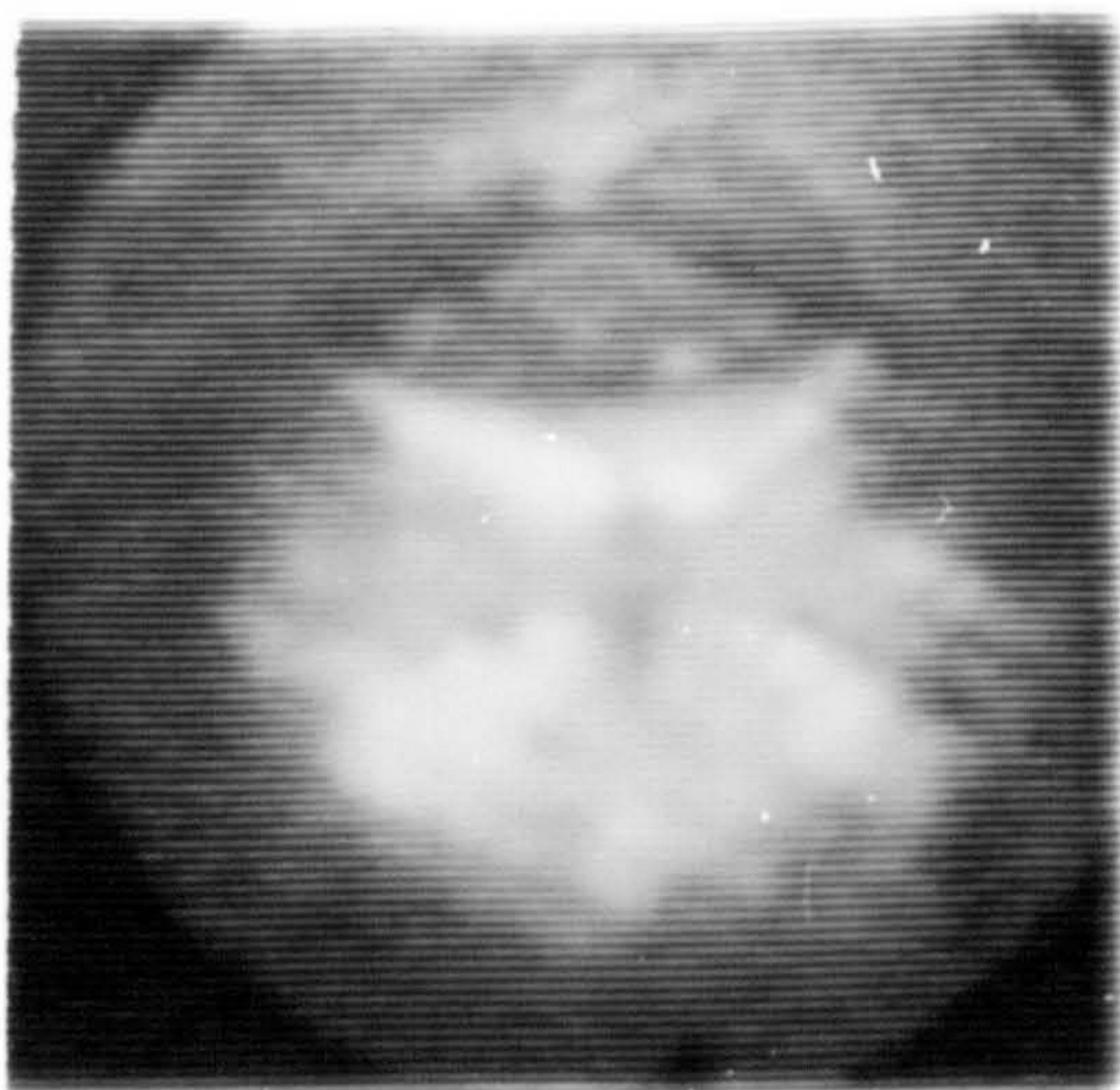


c.

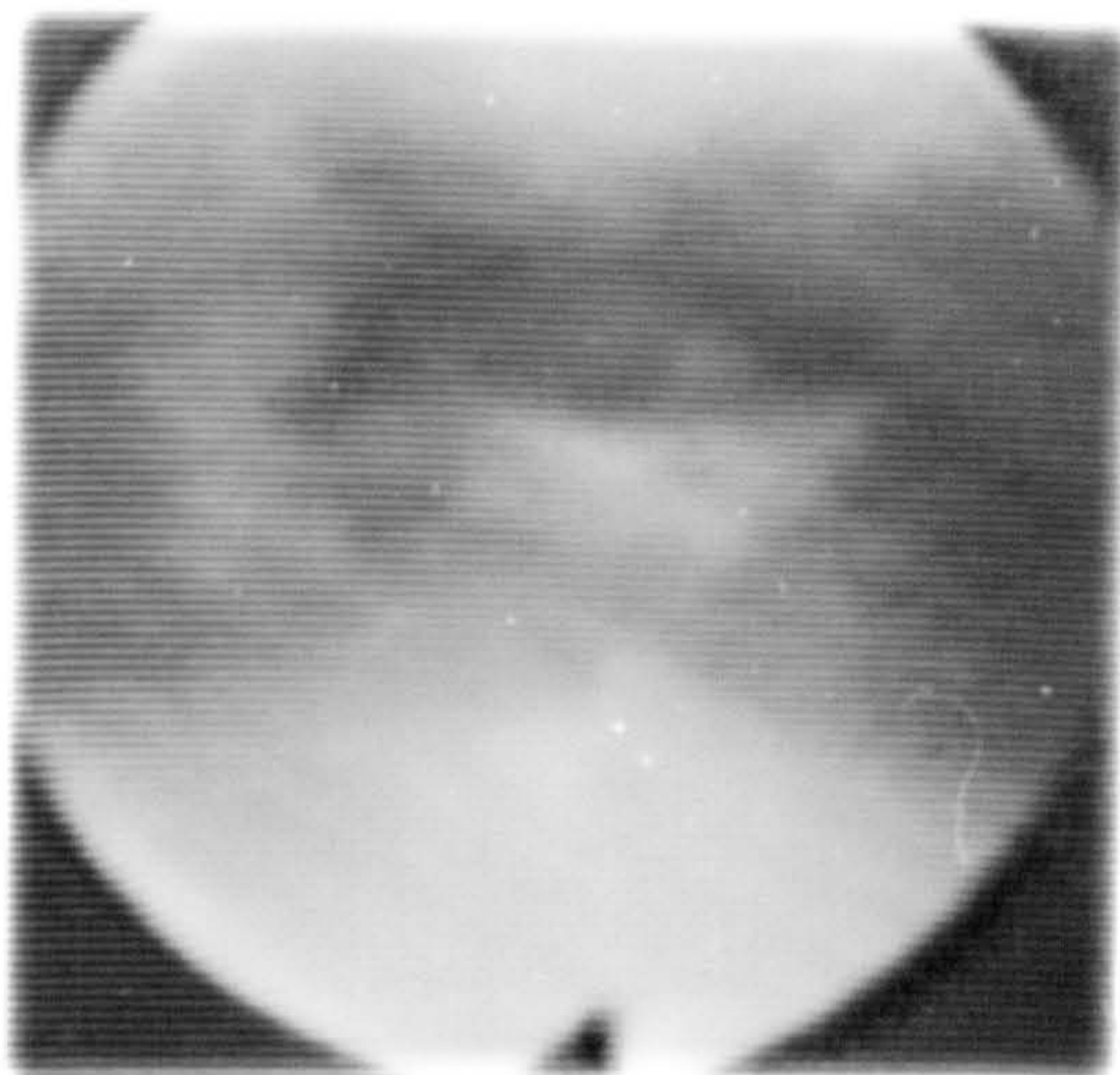


d.

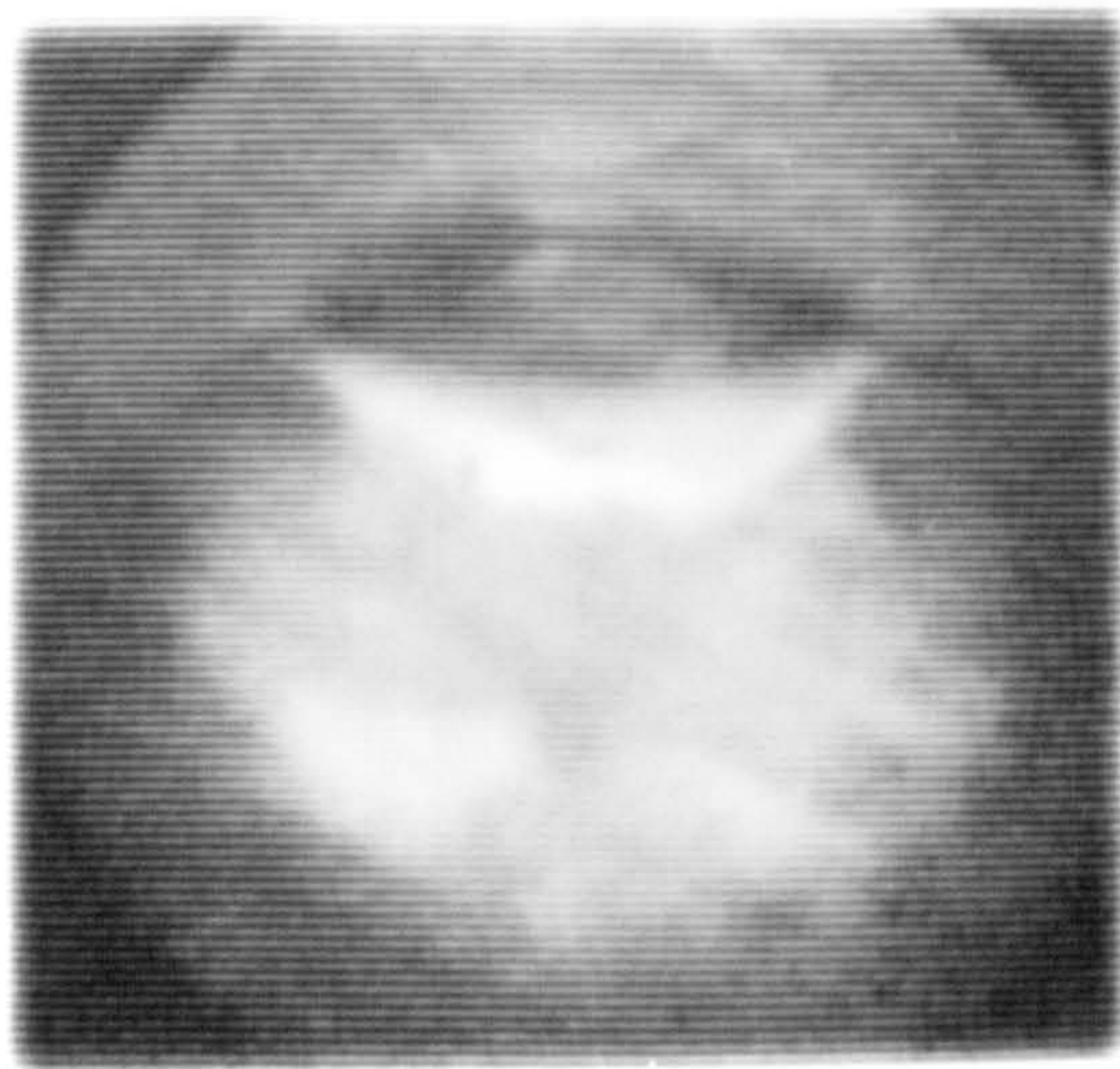
Sketches of Figure 5.3



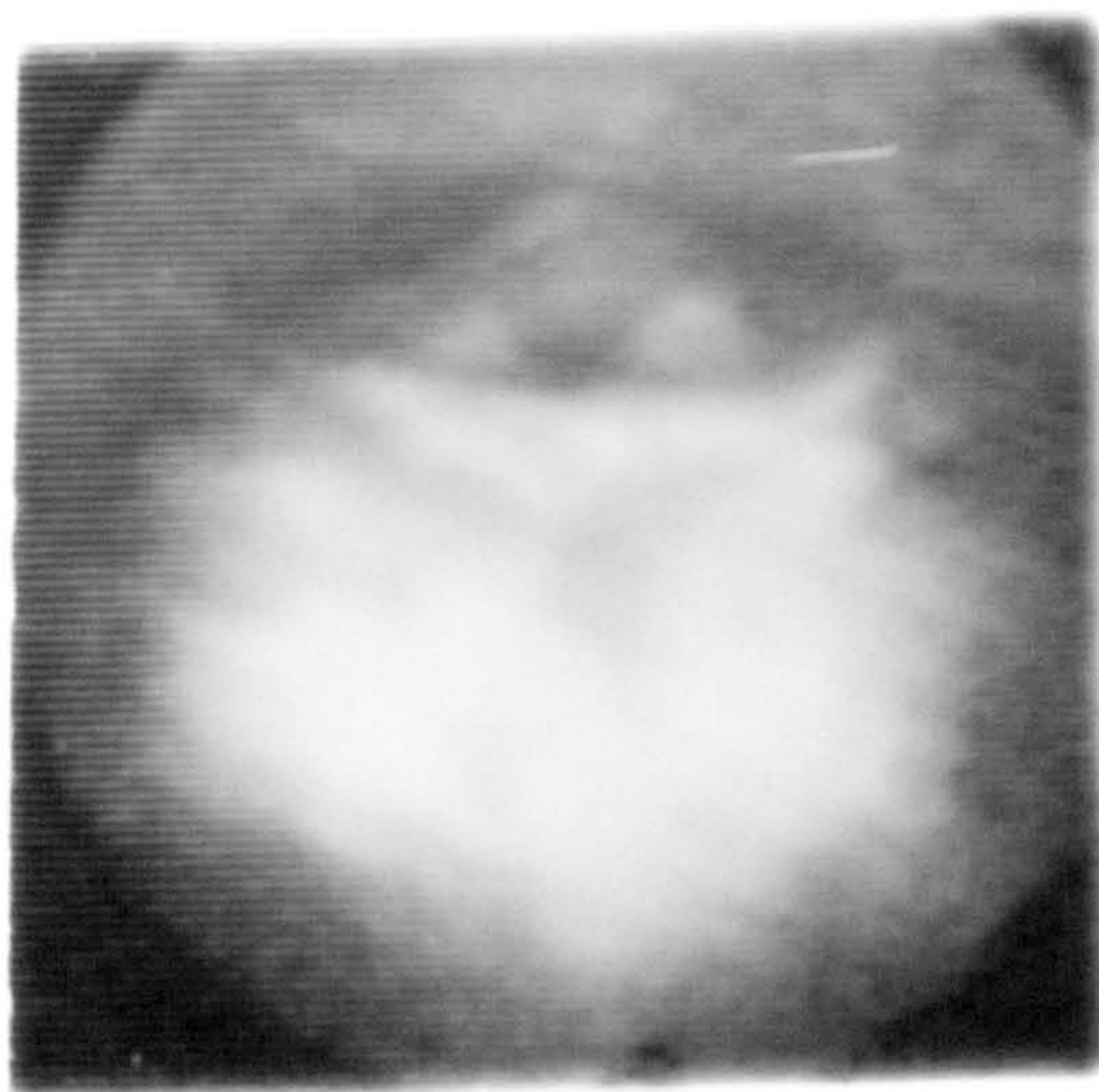
a. /q/ in /qalām/ (FL)



b. /qq/ in /riqqa/ (FL)

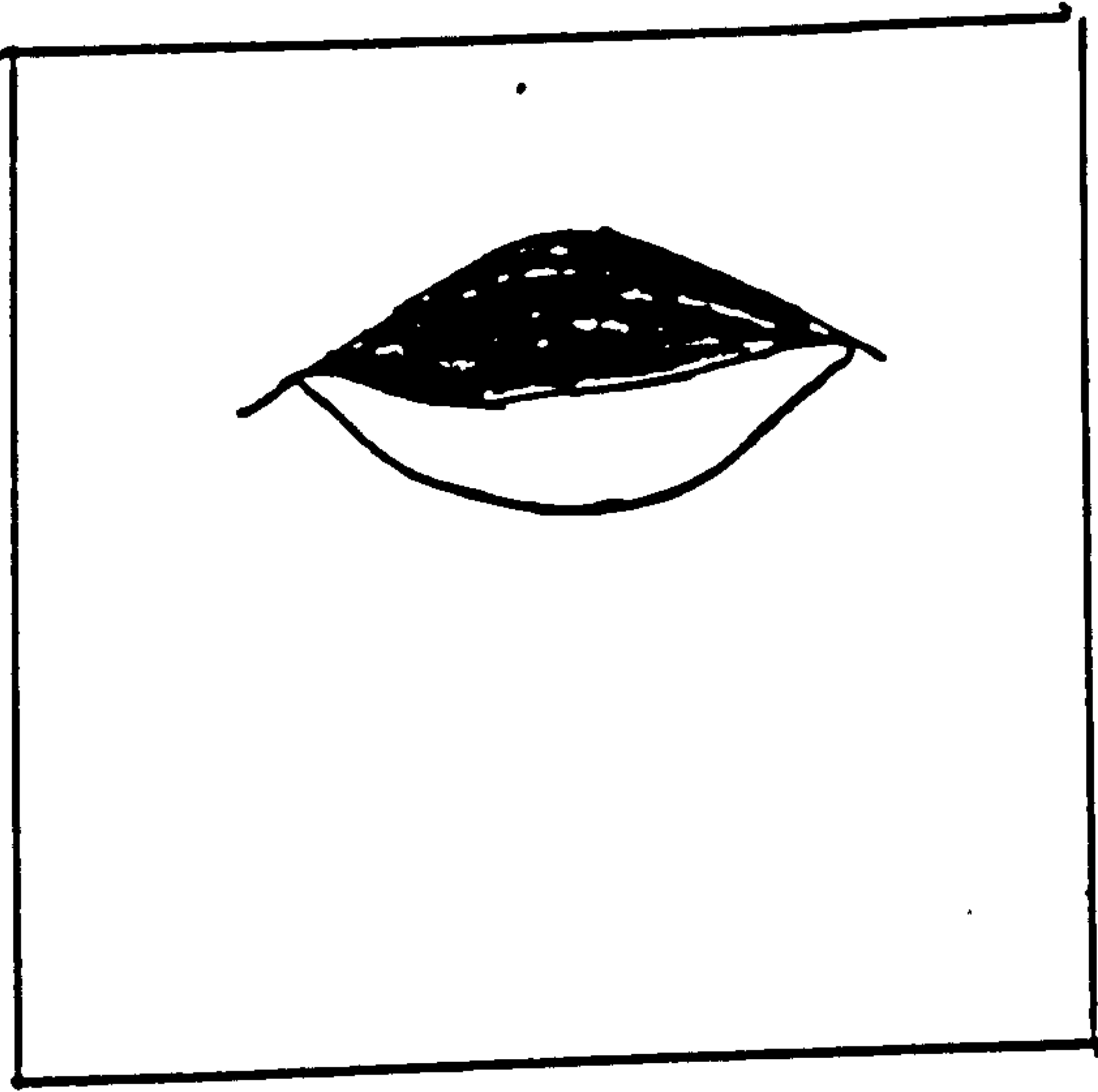


c. /a/ in /riqqa/ (FL)

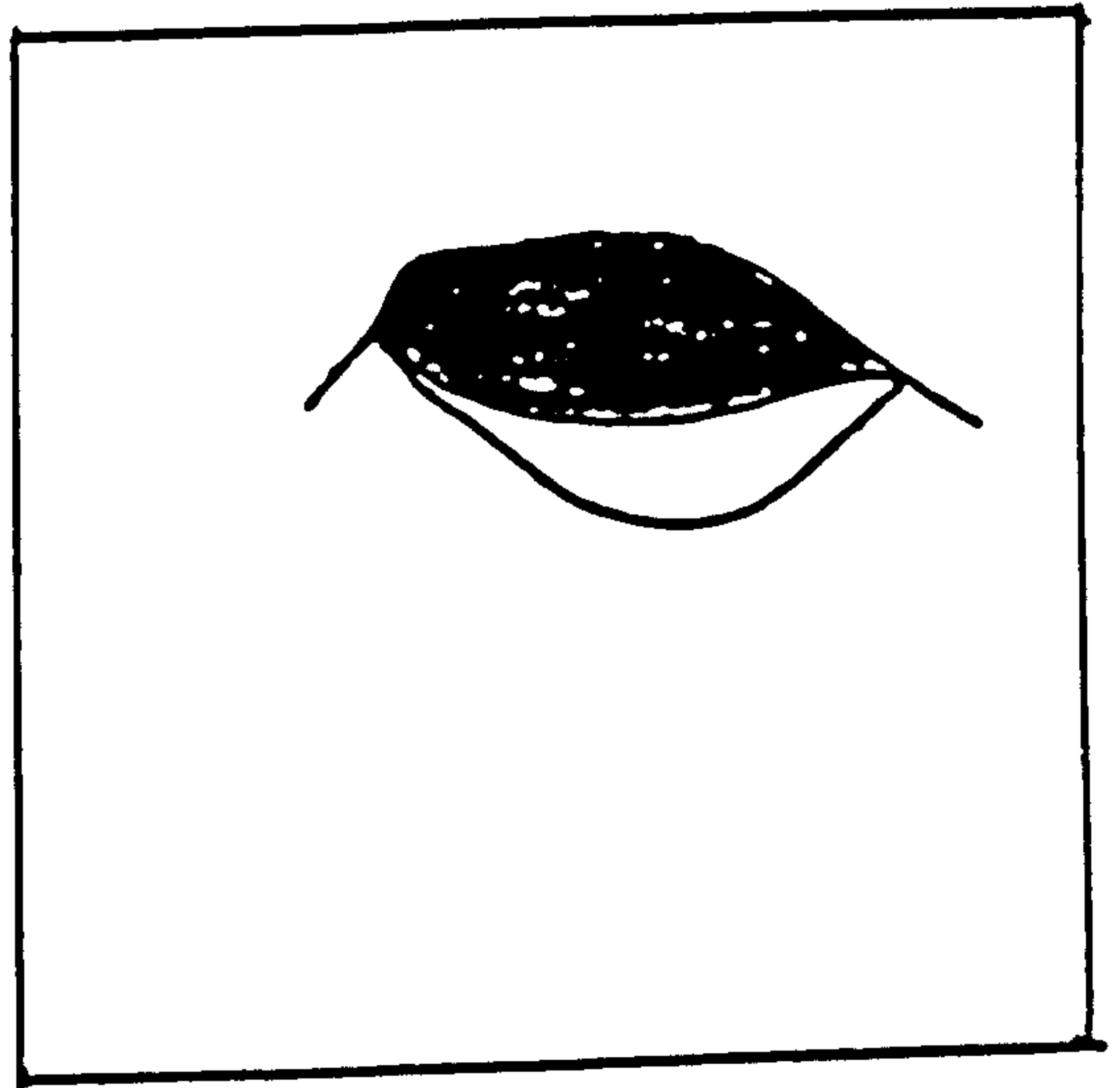


d. /XX/ in /nuXXa:La/ (FL)

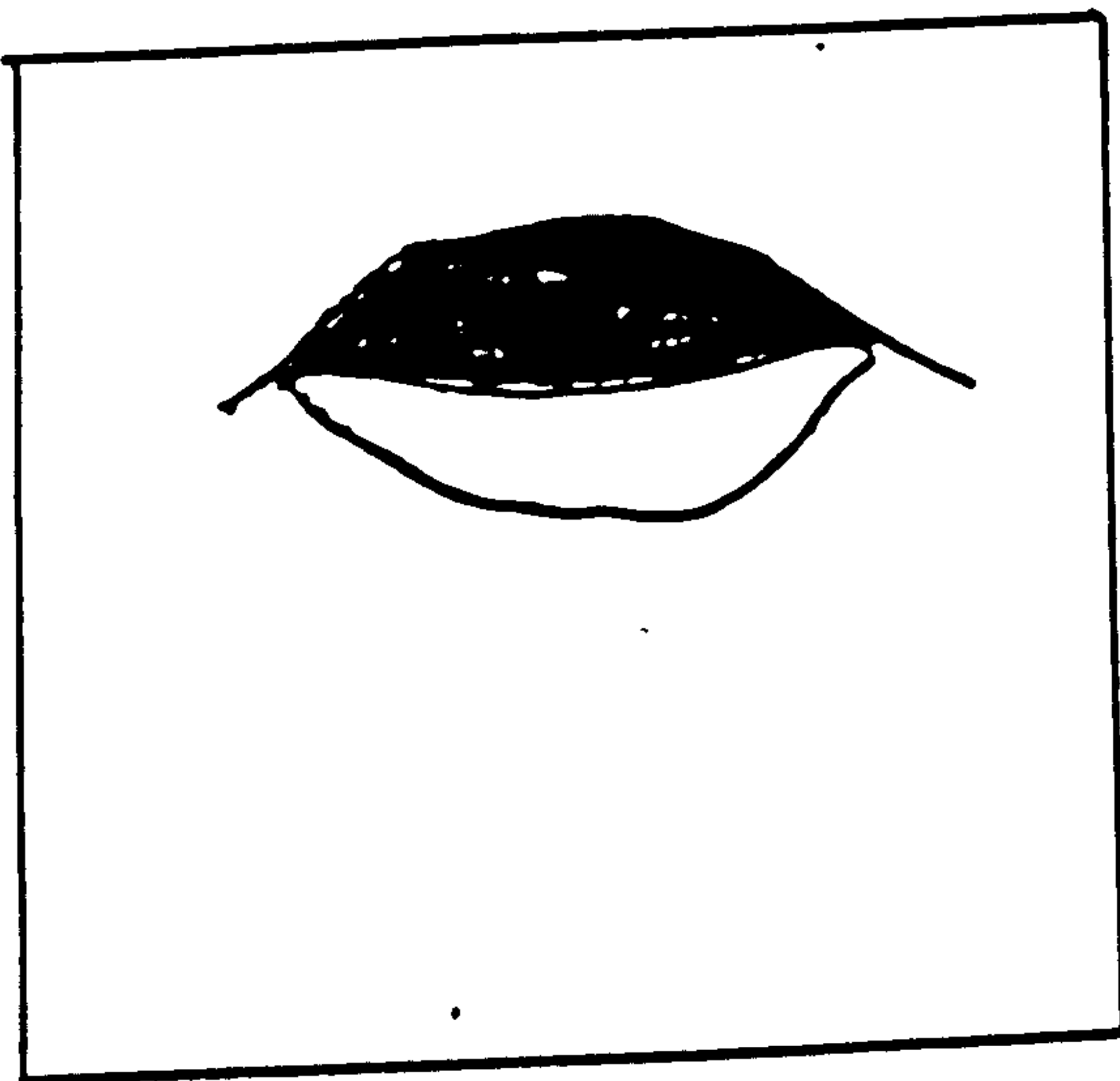
Figure 5.4



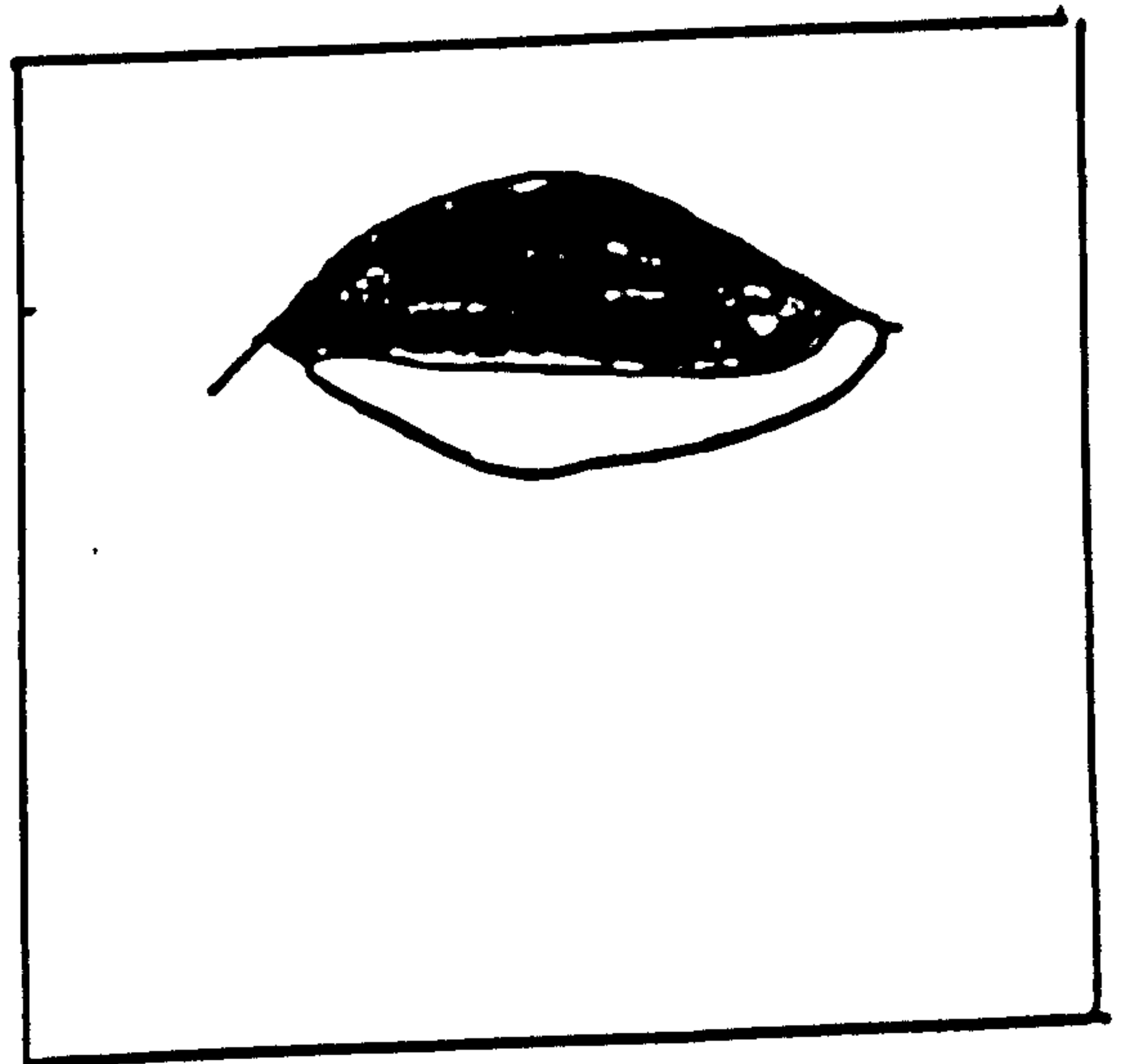
a.



b.



c.



d.

Sketches of Figure 5.4

The tip, body and root of the epiglottis have the same configurations for both /qq/ and the pharyngealized consonants, in spite of the bigger gap that appears between the epiglottis and the root of the tongue, i.e., in the vallecula, for /qq/. This may be due to the fact that the tongue is pulled upwards to achieve a closure with the uvula, hence causing less constriction in the vallecula area.

The space between the root of the tongue and the epiglottis appears to be larger for /qq/ - even larger than for the 'at rest' position. This may be explained as a function of constriction of the epiglottis. The epiglottis moves more towards the back wall of the pharynx for /qq/, hence a bigger space is left between the root of the tongue and the epiglottis, whereas, in the 'at rest' position, the epiglottis does not move and the area surrounding it is not altered. It was also observed that the larynx and the hyoid bone are raised and the jaw is lowered.

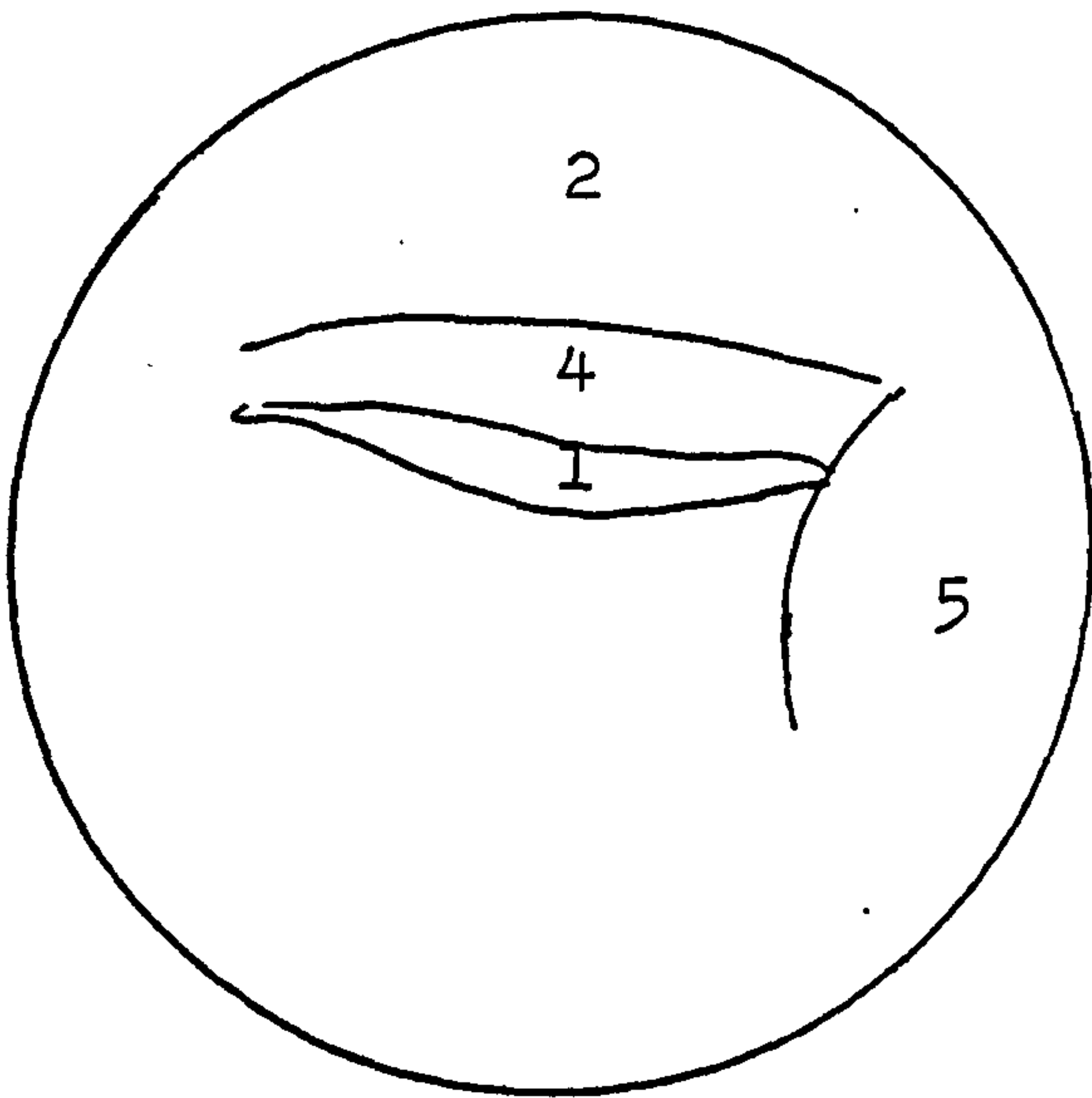
Endoscopic analysis:

Fibreoptic endoscopy of utterances with /q/, confirmed the similarities of this sound to the pharyngealized ones. The epiglottis is seen to move slightly towards the back wall of the pharynx and its tip tends to uncurl until the whole epiglottis has almost an upright position.

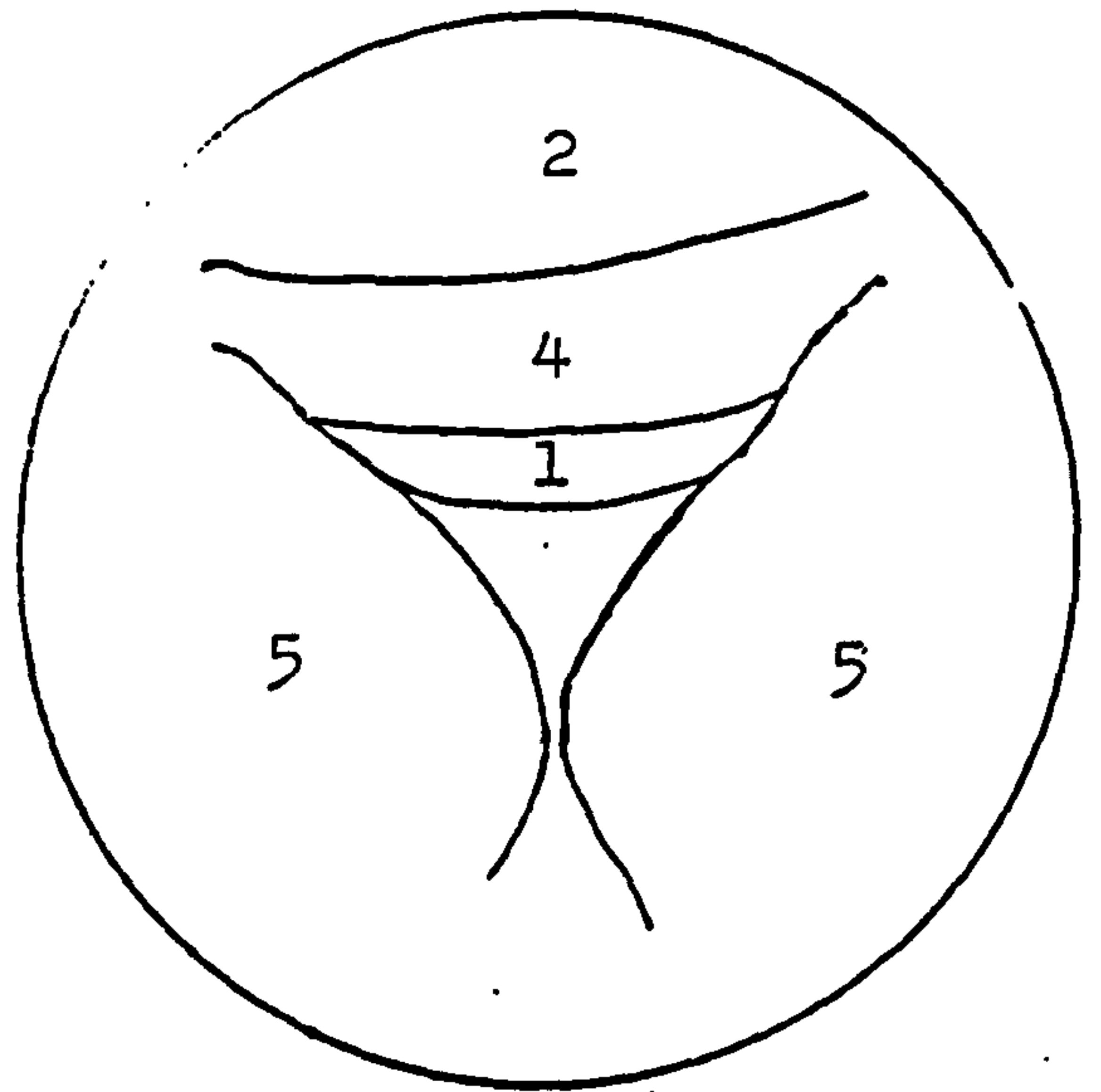
A constriction is also observed in the vallecula area similar to that for the pharyngealized sounds. There appears, also, to be some lateral constriction on the left hand side of the picture for /q/ in /raqi:q/ and /qalam/, Figures 5.3.a and b, and 5.4.a. In /riqqa/, Figure 5.4.b, the tip seems to have uncurled even more, assuming a shape very similar to that for the pharyngealized sounds. It is very difficult to distinguish this view from that of a pharyngealized sound, except to note a greater inward movement of the lateral pharyngeal wall. Had it not been well established that the tongue root assumes a higher position in the pharynx with a closure against the uvula, one would readily interpret what one sees in these video films as the articulation for a pharyngealized sound. One might venture to interpret these observations as showing the articulatory position just before complete constriction. The tongue moving backward and the root being pulled towards the back wall of the pharynx could be taken as one step towards the target position for /q/. This seems to correlate well with the videofluorographic findings of /g/ in /gaʒʒ/, Figure 5.9.a, where two movements of the tongue root were observed, first horizontally forming a constriction against the back wall of the pharynx, and secondly with an upward movement of the root of the tongue towards the uvula to form a constriction. Because there are no examples of /q/ in these

videofluorographic recordings, a conclusion regarding the movement of the articulators for /q/ is being deduced from the videofluorographic findings for /g/ in /gaʒʒ/. This is justified also by the similarity of the lateral views of /q/ in the X-ray tracing of /'ba:q/, the xeroradiographic picture of /riqqa/ and that of the videofluorographic picture of /g/ in /gaʒʒ/.

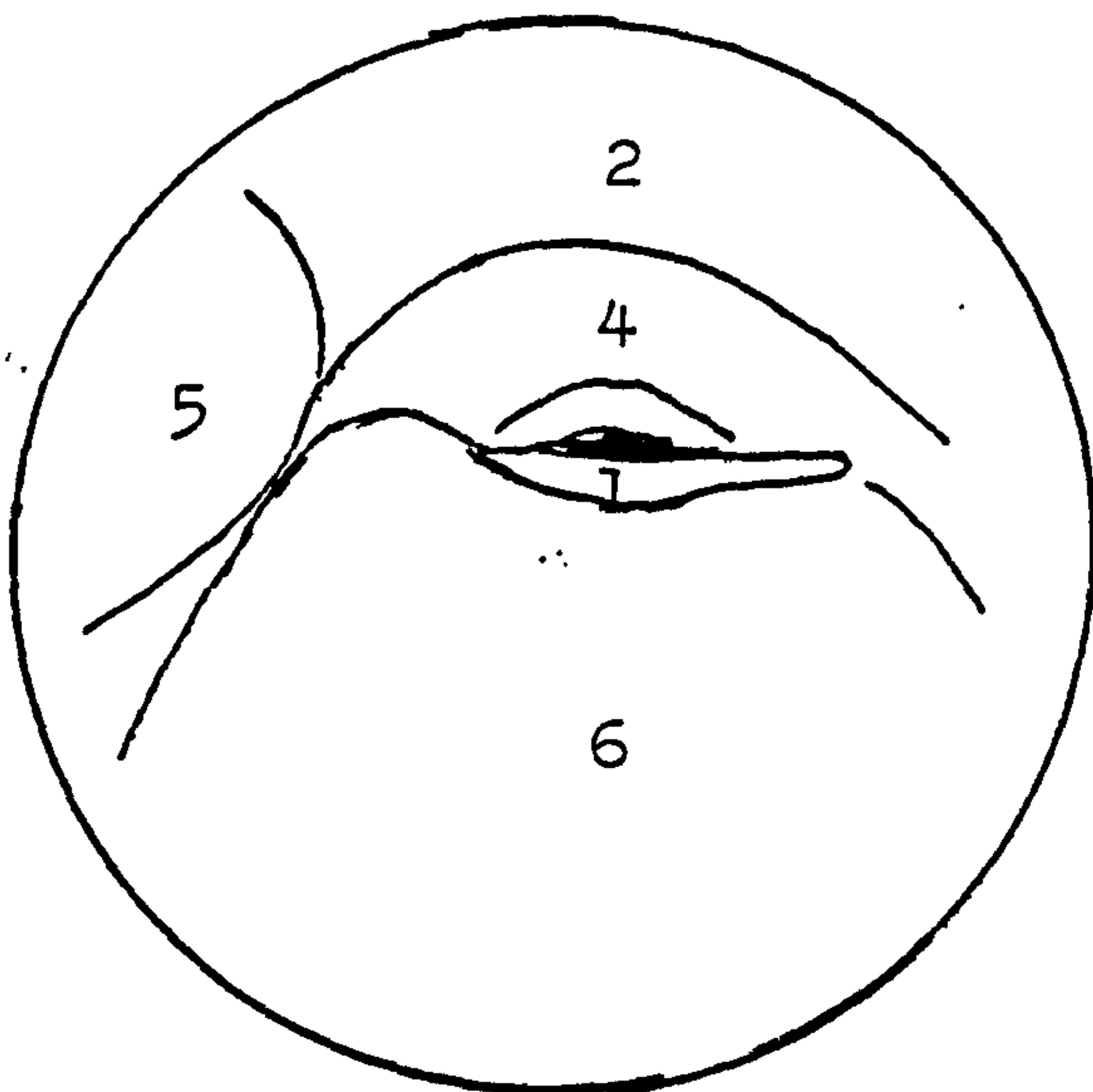
A great constriction of the lateral walls of the pharynx is observed for the Iraqi subject, (SA), during the articulation of /q/. Both walls move inward and almost touch. Unfortunately, it was not possible to get good records of the movement of the lateral walls of the pharynx to include in the description because the rapid movement of the walls interferes with the position of the tip of the endoscope. Moreover, the place of the lateral constriction is above the level of the epiglottis, that is, nearer to the distal end of the endoscope, and there is, unfortunately, so great a reflection of the viewing light that almost the whole of this important area shows completely white, but Figures 5.5.a, b, and c show sketches of /q/ in /qalam/, /raqi:q/ and /riqqa/ respectively. In /qalam/, the epiglottis leaves its normal position in a movement which tends to take it downwards and backwards towards the back wall of the pharynx. The upper surface of the epiglottis uncurls to some extent without moving closer to the back wall of the pharynx. The lateral wall



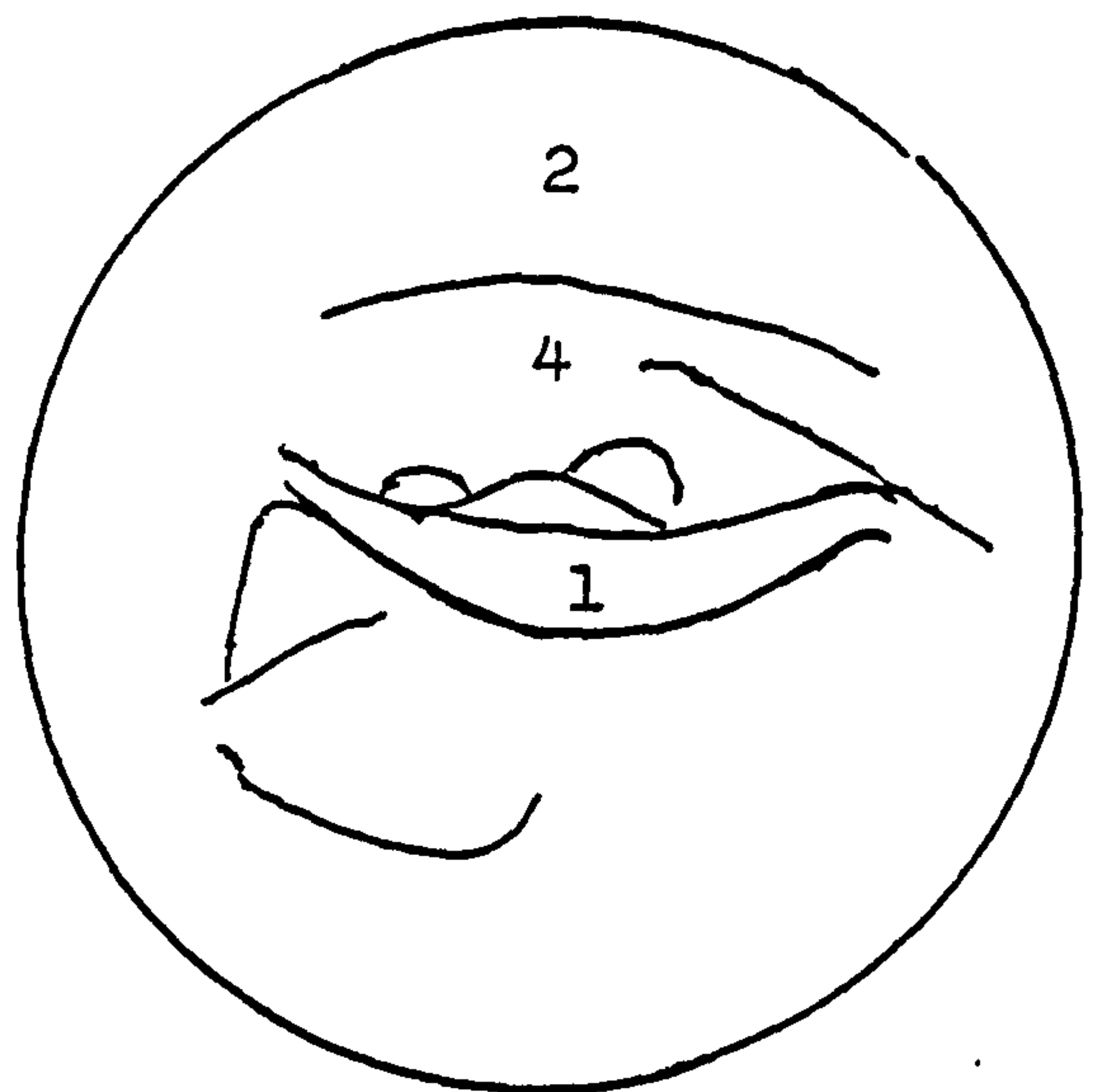
a. /q/ in /qalam/ (SA)



b. /q/ in /raqi:q/ (SA)



c. /qq/ in /riqqa/ (FL)



d. /X/ in /Xaṣṣ/ (FL)

Figure 5.5 See chapter 2 for key.

of the pharynx comes in contact with the lateral part of the epiglottis. The tongue root appears in the picture retracting.

In /raqi:q/ and /riqqa/, the most striking example of the lateral walls movement of the pharynx appears in these two examples. The lateral walls move inwardly until they come in contact with each other. The epiglottis moves towards the back wall of the pharynx until it assumes the position that is similar to that of /q/ in /qalam/. It is very difficult to tell how far the tongue goes backward.

The movement of the lateral walls is extremely rapid in the case of subject (MB), and it appears to occur prior to the movement of the epiglottis towards the back wall of the pharynx. However, for the Iraqi subject, (SA), the lateral wall movement seems to follow the first part of the movement of the articulators towards the closure position; that is, the tongue seems to move backwards towards the back wall of the pharynx, forming a constriction similar to that of a pharyngealized sound. This results in two constrictions in the pharynx, first, an antero-posterior one in the vallecula area, and second, one caused by the inward movement of the back wall of the pharynx. The next stage effects a lateral movement of the walls of the pharynx, which is very large in the case of this Iraqi subject.

As described above, because there is such a rapid and almost simultaneous movement of the lateral walls of the pharynx, the epiglottis and the tongue, it is extremely difficult to determine which part moves first. Examples of /q/ of utterances said by (MB) show that lateral wall movement occurs prior to that of the epiglottis or the root of the tongue. This lateral constriction may occur in two ways; either one or both walls move inward, and there is a synchronised movement of the root of the tongue towards the back wall of the pharynx, or it follows immediately after; this movement of the tongue still taking place a little while after the lateral constriction has ceased. Summing up, one can say that the articulation of /q/ in any position in an utterance results in a) a movement of the epiglottis towards the back wall of the pharynx, followed by b) the movement of the lateral walls, either a strong one of both walls as in the case of the Iraqi subject, or of only one wall. There is also, simultaneously, a backward movement of the root of the tongue towards the back wall of the pharynx.

In all the examples containing vowels adjacent to /q/, i.e., the vowels /a/ and /i/, in examples of Figures 5.3.c and d, and 5.4.c, no lateral wall movement was observed during their articulation. Although the epiglottis performs a different movement for the different vowels from that for /q/, it retains its retracted position as a result of /q/, that

is, it moves only slightly forward for the close front vowel /i/. As for the vowel /a/, because it is an open centralized vowel, the change is very small indeed.

Endoscopic findings of lateral wall movement apply to all the subjects who took part in these experiments regardless of the difference of the dialects of these subjects or sex. All four subjects exhibited lateral wall movement of the pharynx in various degrees. One can conclude that an articulation of Arabic /q/, whatever the speaker's dialect may be, requires a lateral constriction of the pharynx as well as an antero-posterior constriction of the tongue root and back wall of the pharynx.

Minifie, et. al., (1970), in their study of the movement of the lateral walls using ultrasound, found that movement of one lateral pharyngeal wall was "as large as 5 mm. at a position on the pharynx approximately 1 cm. below the angle of the mandible". They found lateral pharyngeal wall movement to be great on low vowels, compared to that of high vowels. They also found that the extent of pharyngeal wall movement for the consonants depends on the adjacent vowels. On the other thand, Collins (1970), cited in Beckett and Hallett (1971), found that high vowels have greater lateral wall movement. This fiberoptic endoscopy analysis revealed some lateral pharyngeal wall movement which did not follow a consistent pattern with regard to the adjacent vowels.

Lateral pharyngeal wall movement occurs for the uvular consonants /q/, /X/ and /g/ with a unique movement for /q/, where both walls draw inward and almost touch each other. This takes place irrespective of which vowel is adjacent to /q/, whether /q/ is in an initial or word final position. This movement appears to occur high up in the pharynx.

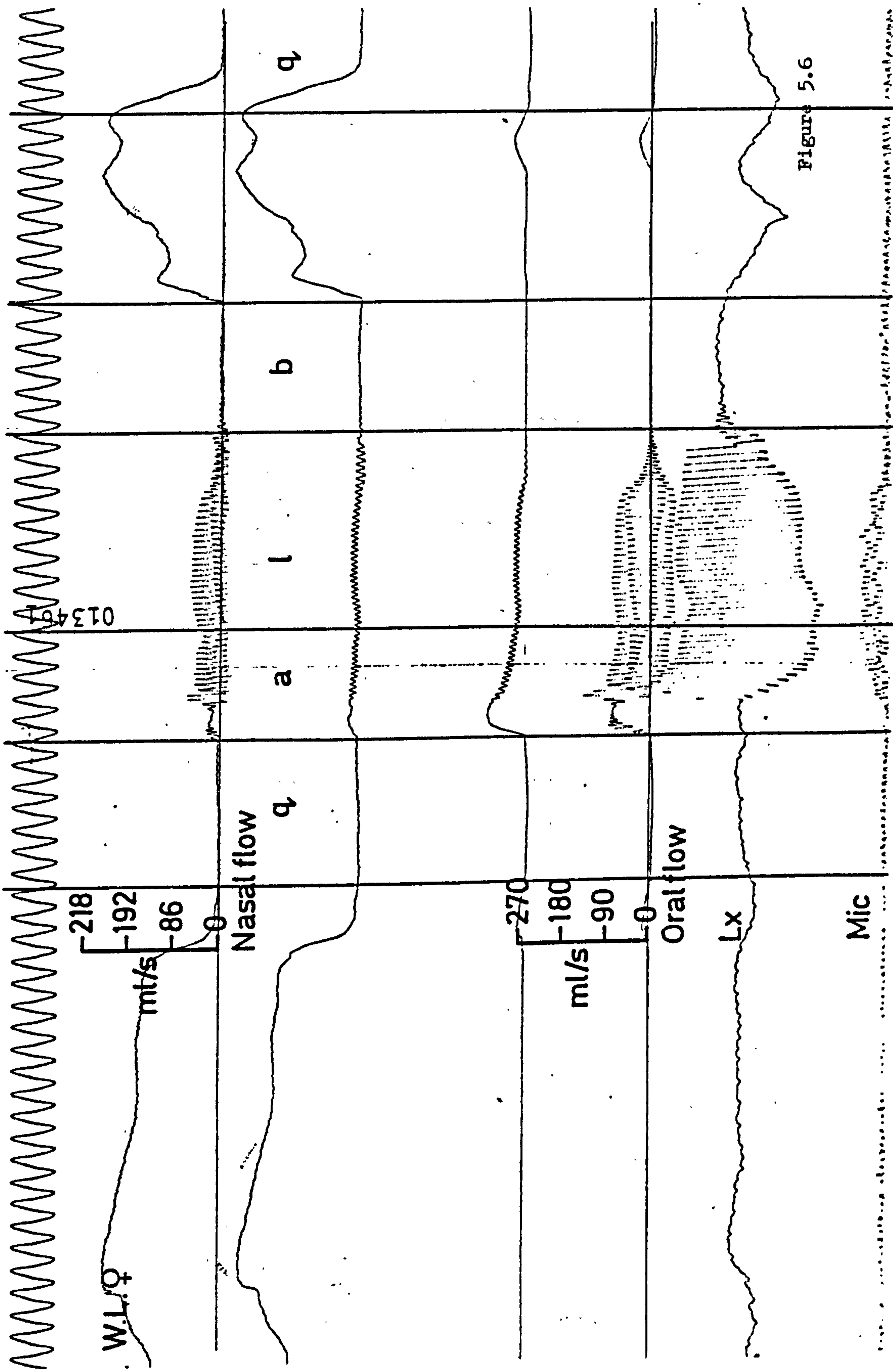
Dickson and Dickson (1972), cited in Zagzebski (1975), suggest that the levator muscle alone is responsible for lateral pharyngeal wall movement. Zagzebski, on the other hand, points out that it is likely that it is the fibres of the superior constrictor that play an important role during velopharyngeal closure by drawing the lateral pharyngeal walls towards each other. This conclusion is supported by electromyographic studies of Fritzell (1969), which showed "low-level activity in the superior constrictor, as well as activity in the levator that correlated with velopharyngeal closure for speech". Several authors, Podvinek (1952), Bosma and Fletcher (1962), have described the mechanisms by which constriction of the palatopharyngeus muscle would result in "adduction" of the posterior faucal pillars, and "mesial" movement of the lateral pharyngeal walls. Electromyographic data from this muscle, Fritzell (1969), indicates that palatopharyngeus activity is not highly correlated with velopharyngeal closure, but does coincide with production of the vowel /a/. Fritzell's conclusion that the

action of the palatopharyngeus may pull the pharyngeal walls "mesially" during /a/ appears to correlate with the actual movement patterns of the lateral pharyngeal wall at the level of the angle of the mandible. Ultrasound data shows that the lower walls move "mesially", mainly during low vowel production.

Airflow analysis:

Figure 5.6 shows the second of three consecutive utterances of /qalb/ said by the author of this thesis. There is good consistency between the three examples, except for a longer, non-significant nasal outflow of air after the first. Nasal 'escape' of air is not at all unusual for this subject. Here, in each item, nasal flow starts plosively rinally, (i.e., a rapid onset of nasal flow) which can be considered as either a nasal release for the /b/, or as expiratory air having a respiratory function. The final sound, therefore, /b/, may be, strictly speaking, nasally-exploded but one would have to take into account whether plosion was audible or not.

The first segmentation line, at the start of /q/, can only be a tentative one. Though it is drawn at the first point where both oral and nasal flow are zero, the closure movement proper probably started some time before, when nasal flow was being reduced to zero, almost certainly by soft palate action. A small increase in oral flow



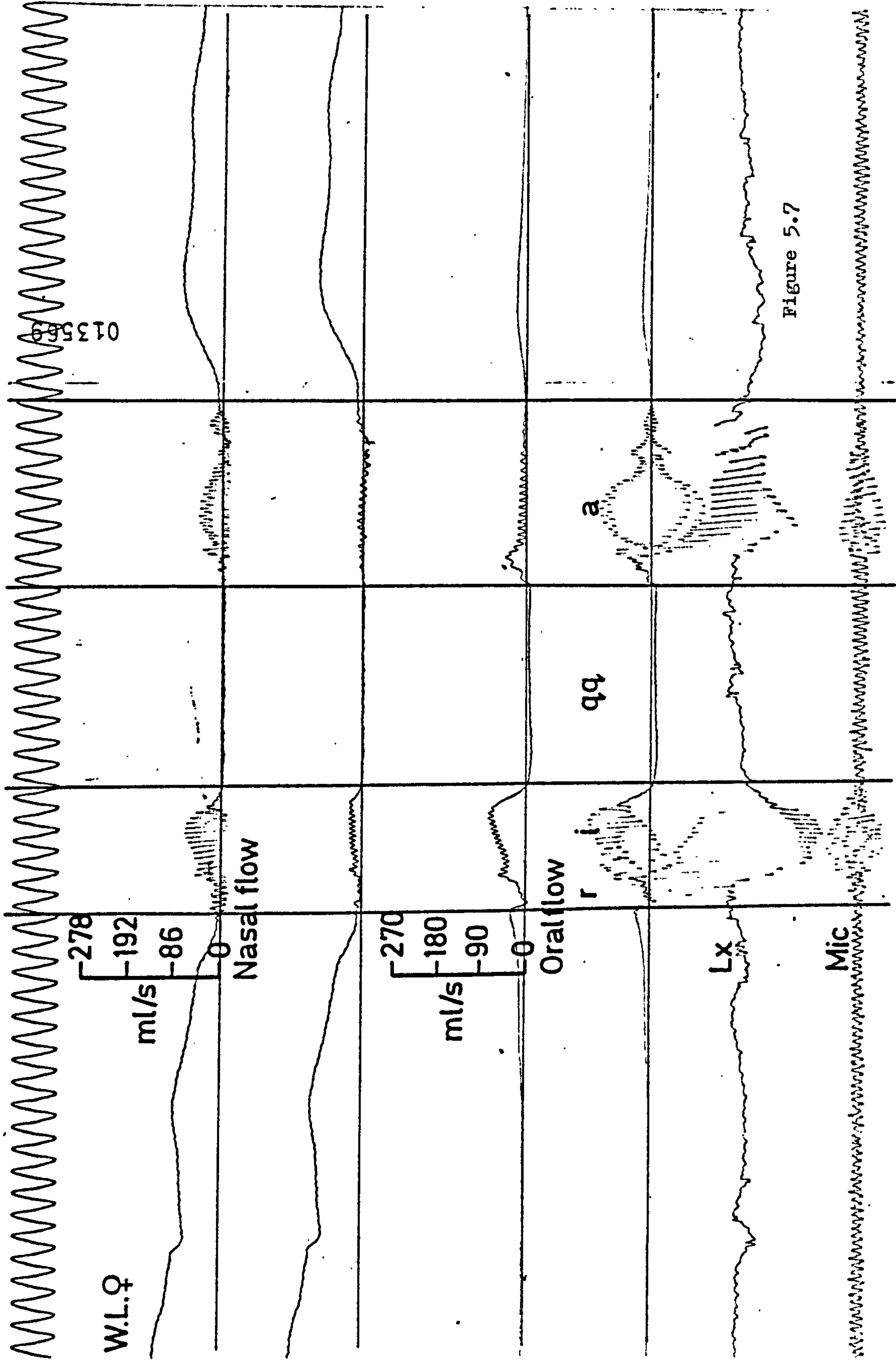
follows immediately, probably from a jaw, tongue, lip or soft-palate change of position.

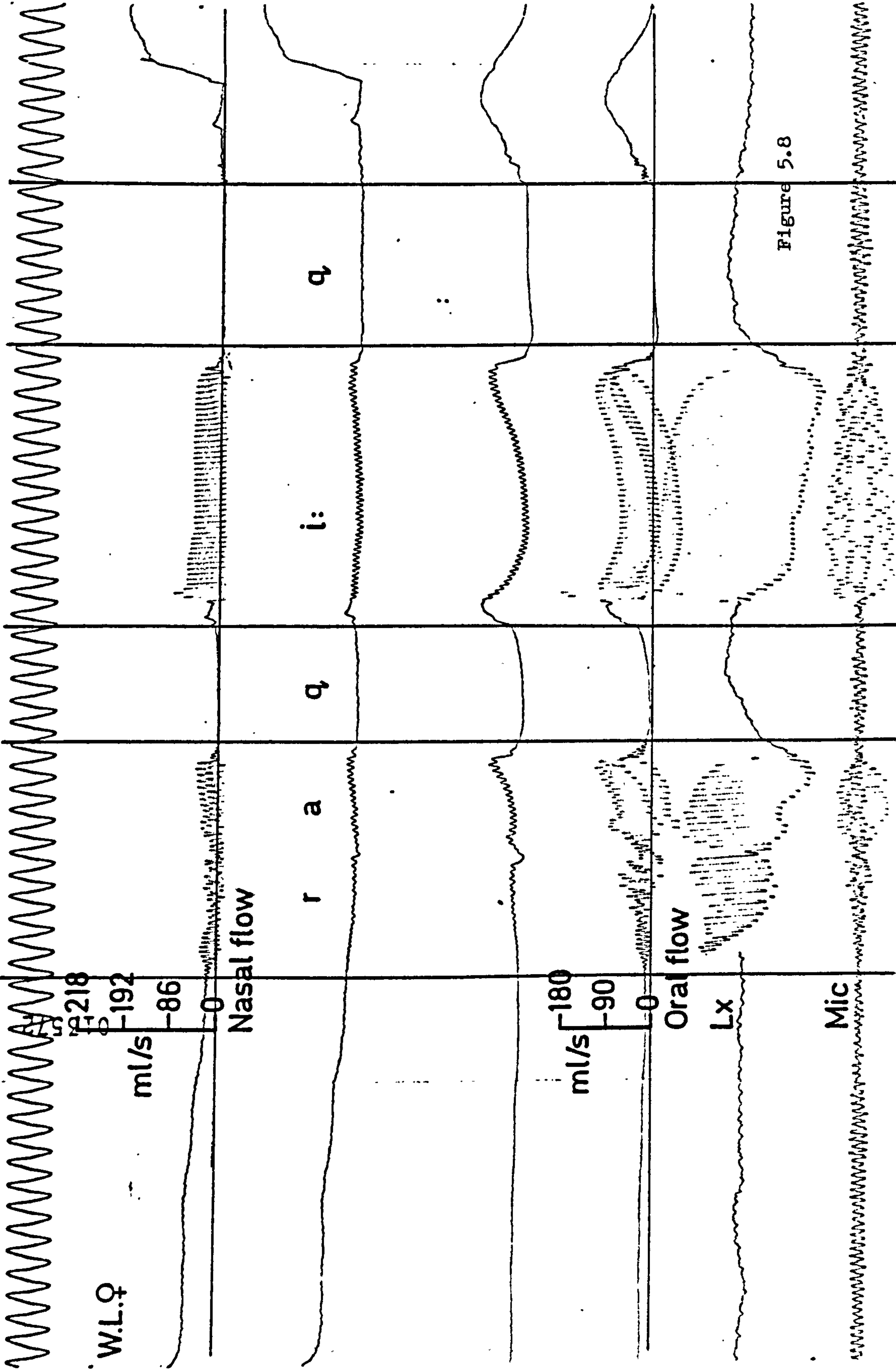
It is pertinent to point out that the apparatus is very sensitive and changes can be shown on these records, which may well not be seen on records made on other types of airflow measuring equipment. Take, for example, this rise in oral flow, occurring at the calibration line. At its peak, the deflection is no more than 1 mm., which represents a flow rate of 9 ml/s; the actual volume change, that is, the quantity of air through the pneumotach screen in this small pulse, can be estimated, taking into account the speed of the paper. The area (representing the volume) can be approximated by a small triangle which has then a height of 1 mm. (9 ml/s), and a length (base) of 1.4 cms. ($\frac{1.4}{25}$ secs = 56 ms). Volume is proportional to the area, which equals $\frac{1}{2}$ base x height = $\frac{1.4}{25.2} \times 9 \text{ ml} = 0.25 \text{ ml}$.

One can see then that although the trace shows clearly that there is an articulatory change, the movement change causing the volume change, may be very small indeed. There is an inflow of oral air during /q/ as segmented here, but again it is small and in this case it is approximately 0.6 ml ($\frac{3.2}{25.2} \times 9 \text{ ml}$). Very good closure then, can be claimed for /q/. Throughout the vowel /a/ and /l/ as segmented here, there is some nasal flow and again one must judge this from a quantitative point of view. On average, the

nasal flow during these two segments is about 10 ml/s, while the oral flow averages about three times greater, which is what would be expected for the open vowel /a/ and the lateral /l/. Nasal flow begins synchronously with oral flow, which may be interpreted as confirming the prime closure by the tongue in the pharynx below the soft palate. When this closure is released and the tongue moves for /a/, the airway is opened to the nasopharynx. The tongue movement possibly weakens the firmness of closure of the soft palate against the back wall of the pharynx and allows this small nasal flow to occur. Oral flow for these two segments (/a/ and /l/) begins with a period of unvoiced plosive air, (but this is of very short duration, ($\frac{0.9}{25} = 36$ ms). It has been included with the vowel as is considered it would be an unnecessarily narrow transcription to segment separately as aspiration. The segmentation line dividing /a/ and /l/ must be considered very tentative indeed; one hears one sound blending smoothly into the other and the airflow traces show no sudden change except for a slight dip in nasal flow. Closure for /b/ is again very tight and ends with the release, nasally, before oral and nasal closure is made again for the last utterance.

The aerograms of /riqqa/ and /raqi:q/, Figures 5.7 and 5.8 respectively, give interesting similarities in pattern and differences in durations. In both, the medial plosive starts with nasal and oral flow being brought to zero or



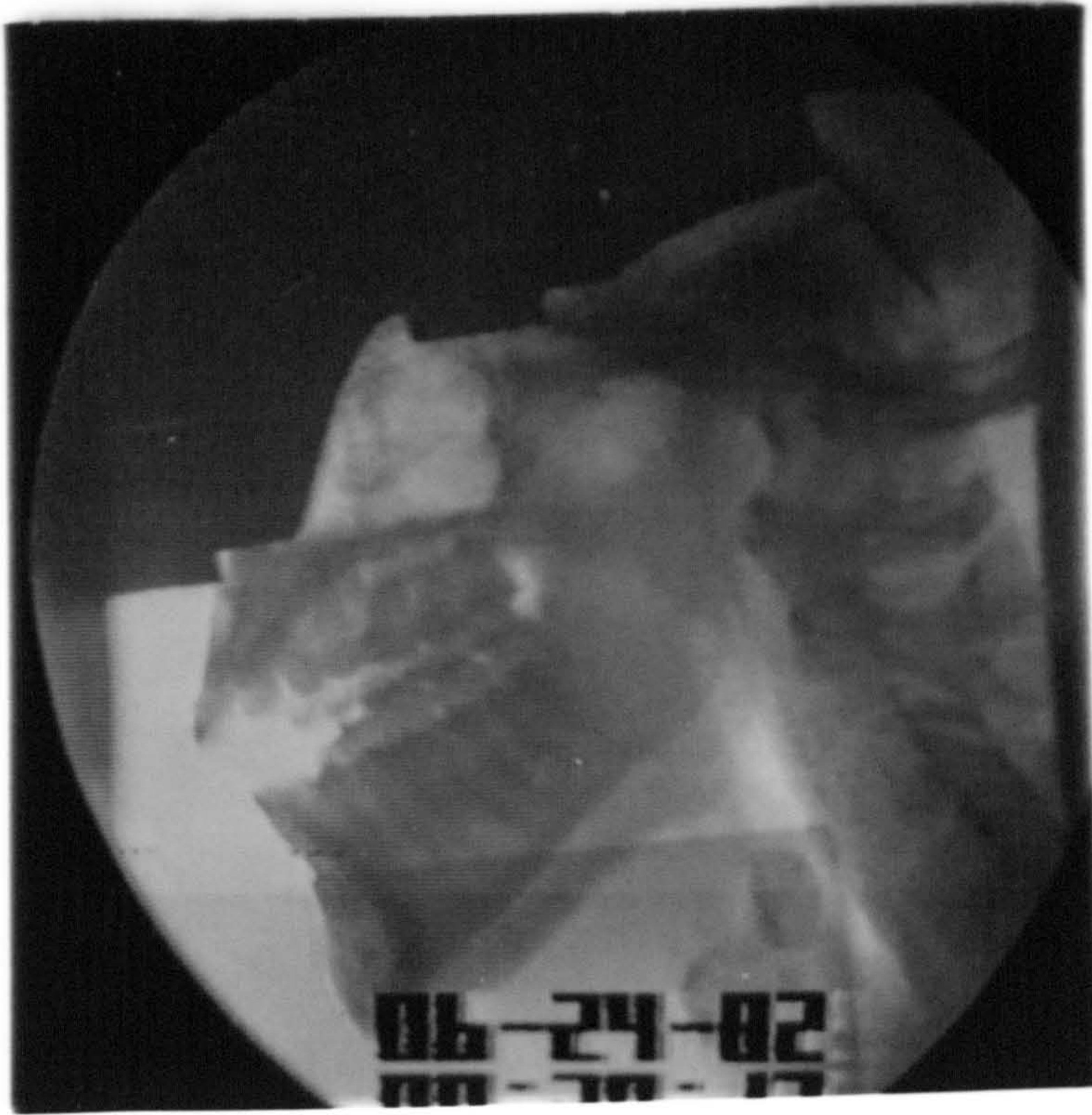


near zero very quickly and in both voicing for the following vowel is delayed after the release by about 25 ms. There is a small nasal flow before and after the non-geminated stop, but not after the geminated one. Zero nasal and oral flow is maintained throughout the geminated, but the non-geminated oral flow may not quite reach zero reflecting the considerable difference in duration between the two, 180 against 104 ms. By contrast, the vowel durations of the non-geminated are much greater than the geminated; final /i:/ 256, as against final /a/ 168 ms and initial /ra/ 208, as against initial /ri/ 116 ms. It should be noted, however, that for /ri/, the one-tap closure for the consonant occurs initially, whereas, for the /ra/, it occurs medially in this first voiced consonant and vowel segment.

5.2 The Uvulars /X/ and /g/ See Appendix I for tables of results.

Videofluorographic analysis:

The videofluorographic pictures of the word /gaʒʒ/, Figure 5.9.a & b, shows that the tongue root and dorsum make a circling motion in the pharynx to produce /g/. The first move is backward with the tongue root, then keeping its retracted position the dorsum moves upwards until it meets the uvula, leaving a narrow space where friction can occur. After the friction phase, the tongue



a. /g/ in /gæʒ/ (FL)



b. /a/ in /gæʒ/ (FL)

Figure 5.9

root again lowers and assumes the position for the following vowel. This is in agreement with Delattre's description of uvulars in Lebanese Arabic (1971).

The tongue assumes the same position for /q/ as for /g/ except that in /q/, the root forms a complete closure with the soft palate, whereas, for /g/ a constriction is formed there instead. The tongue is a little higher for /X/ than for /g/, resulting in a narrower constriction, which produces more friction for /X/. The soft palate is raised and the nasopharynx closed off.

It is seen that the root of the tongue is not as high for /g/ in /gaʒʒ/ as it is for the pharyngealized sounds with /u/.

Endoscopic analysis:

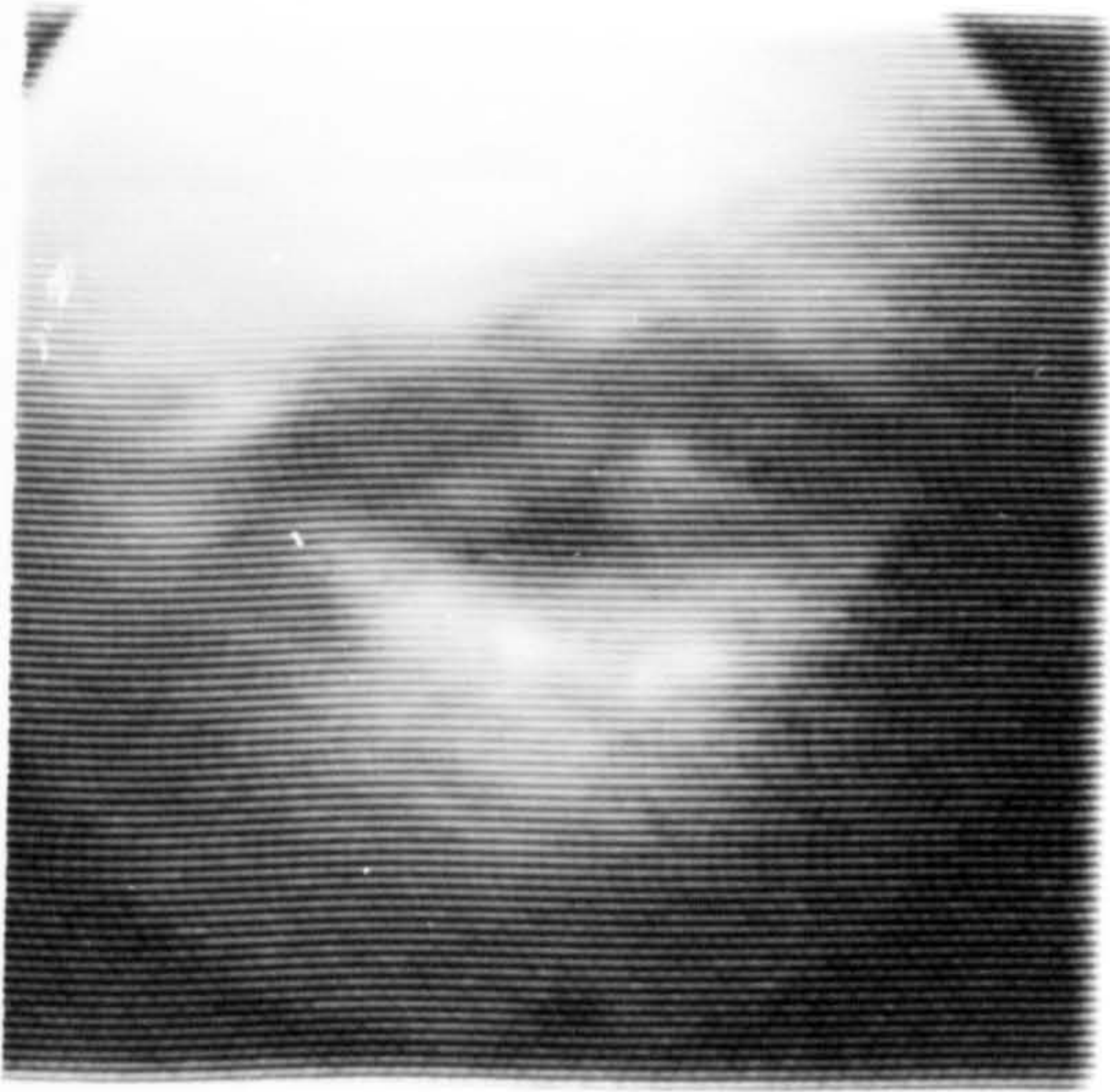
There are clear and definite differences between /q/ and the pair /X/ and /g/; unlike /q/, the uvular fricatives /X/ and /g/ do not have the same articulatory manoeuvring as is observed for the pharyngealized sounds. As a matter of fact, the tip of the epiglottis has a similar shape to that at rest. Though lateral constriction is less marked, but because the epiglottis is almost completely uncurled, it is fairly certain that /g/ and /X/ behave like /q/ and that what is seen is the first stage toward an uvular constriction. The constriction

seems to affect the whole area, that is, the whole pharynx, postero-anterior and lateral.

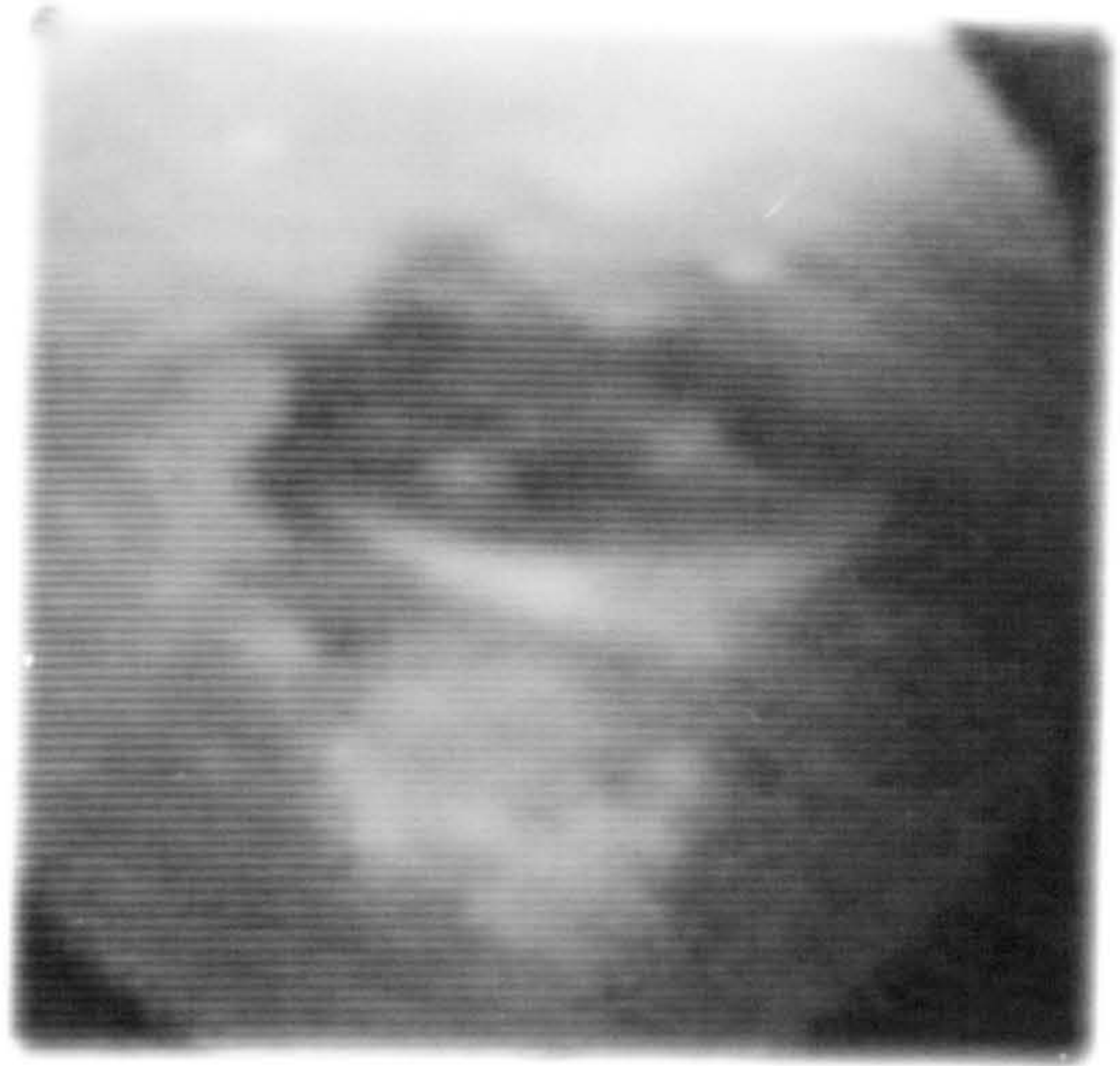
In the word /maTbiX/, Figure 5.10.d, even though /X/ is preceded by the close front vowel /i/, the same configuration of the articulators occurs. This may be interpreted as a coarticulation effect of the pharyngealized /T/ in the first syllable.

/g/ and /X/ of utterances said by subject (MB) have a similar position of the epiglottis against the back wall of the pharynx as that found with an open vowel. Though there is a lateral wall movement, it is not as great as for /q/.

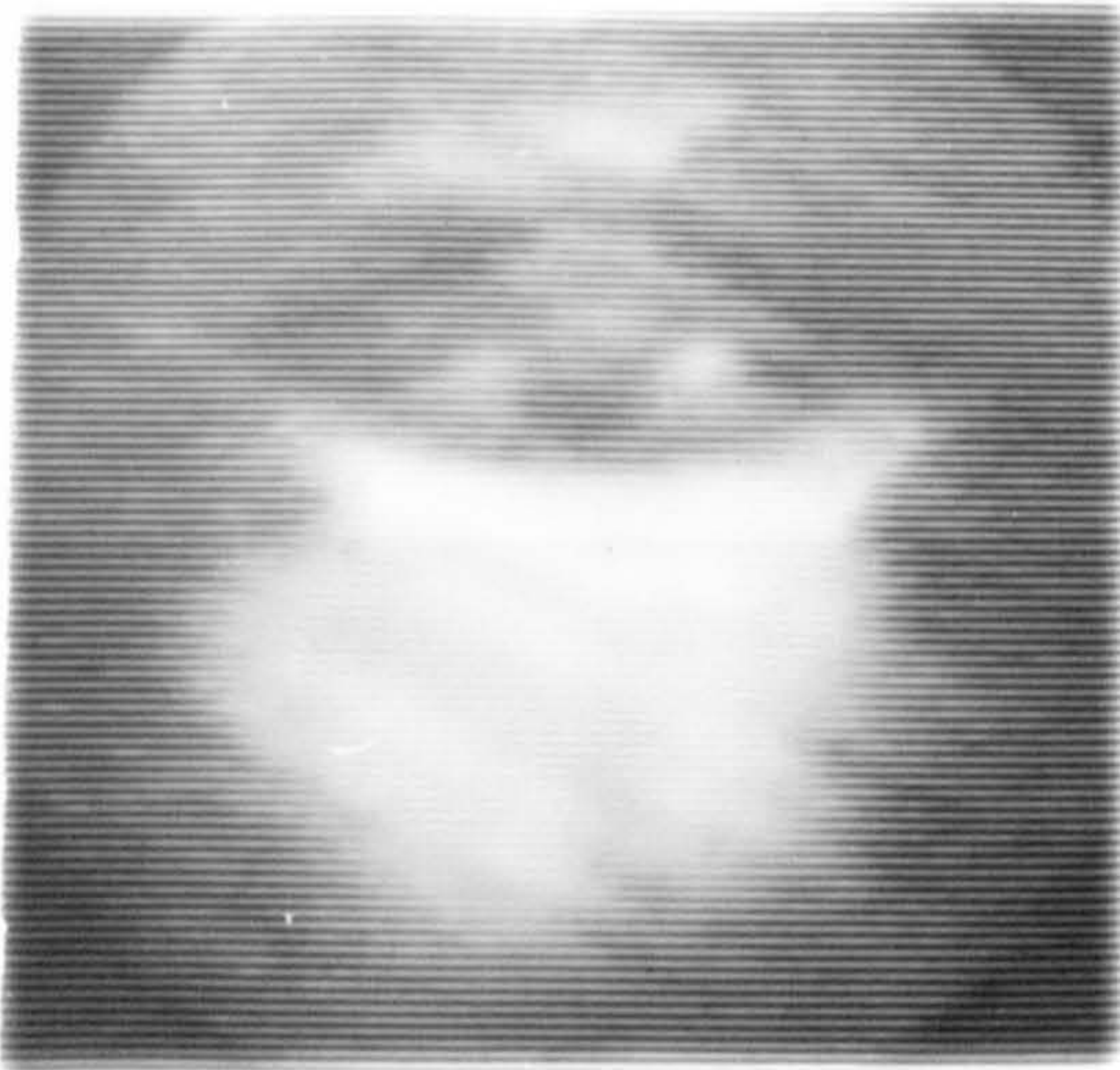
Fibreoptic endoscopy shows that there is no significant difference in the position of the articulators during the production of vowels preceded by either /g/ or /X/. However, when /X/ and /g/ are adjacent to vowels, Figures 5.4.d of /X/ in /nuXXa:la/ and Figures 5.9.a, c and d of /X/ in /Xaʒʒ/, /lda:Xil/ and /maTbiX/ respectively. Also, Figures 5.11.c and d of /g/ in /gaʒʒ/ and /ga:di/ as said by FL, and Figure 5.5.d of the sketch /X/ in /Xaʒʒ/, where the most obvious feature is the constriction of the lateral pharyngeal walls. The epiglottis moves backwards without being depressed downwards as in the case of the pharyngealized consonants, leaving the size of the upper edge unchanged. The lateral walls of the pharynx touch the lateral walls of the epiglottis. It is difficult to



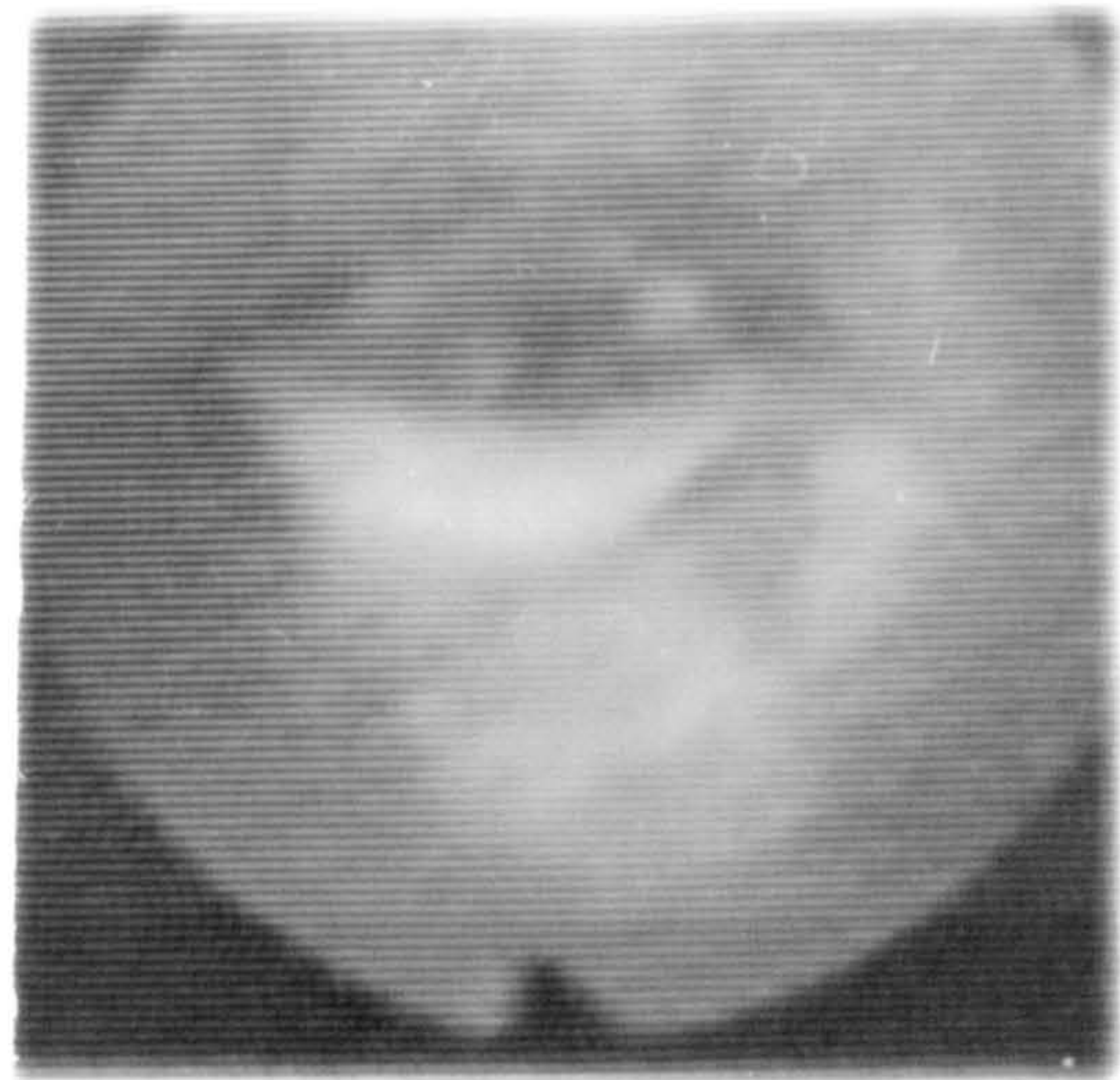
a. /X/ in /Xa~~ss~~/ (FL)



b. /X/ (FL)

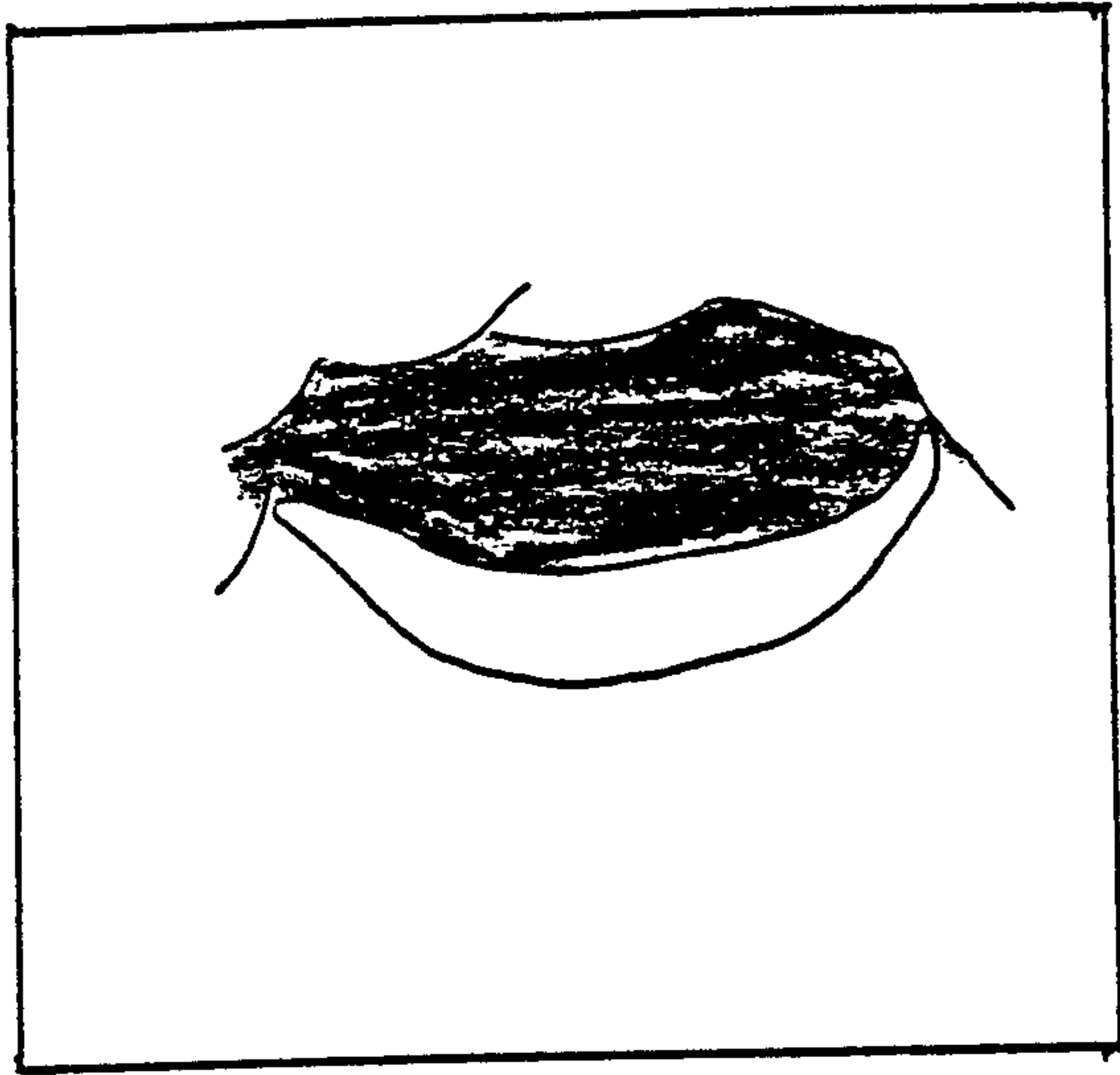


c. /X/ in /lda:Xil/ (FL)

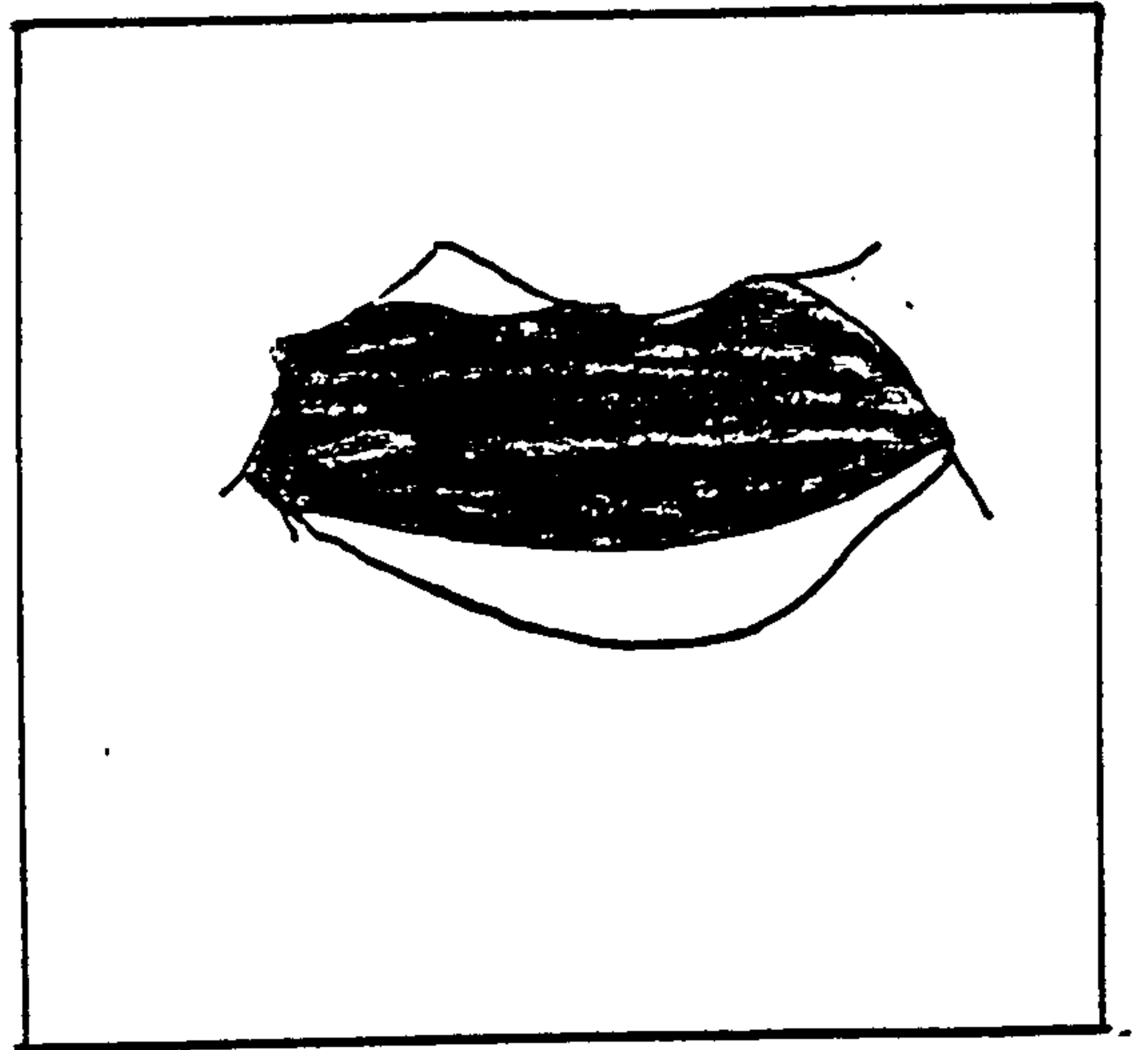


d. /X/ in /maTbiX/ (FL)

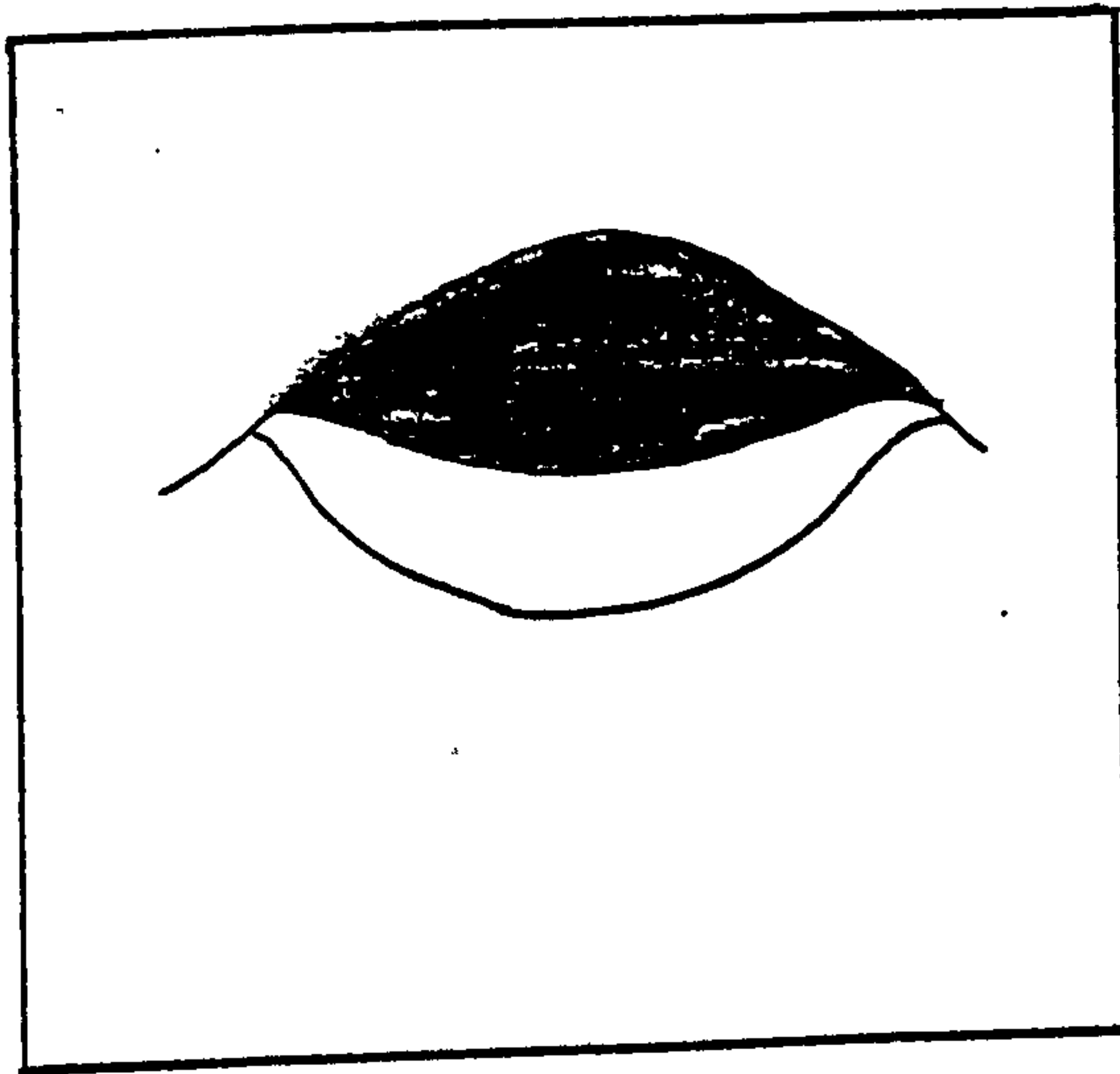
Figure 5.10



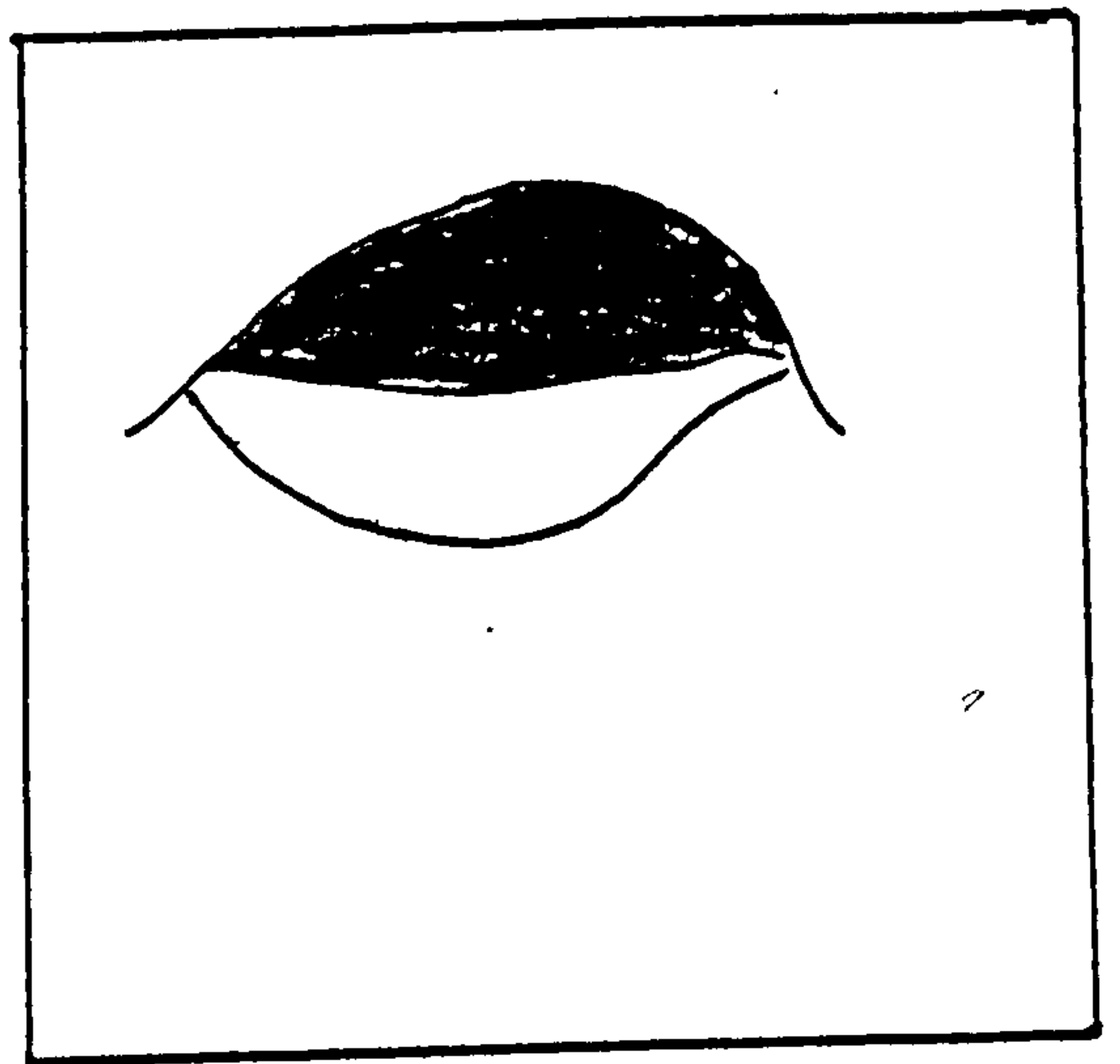
a.



b.



c.



d.

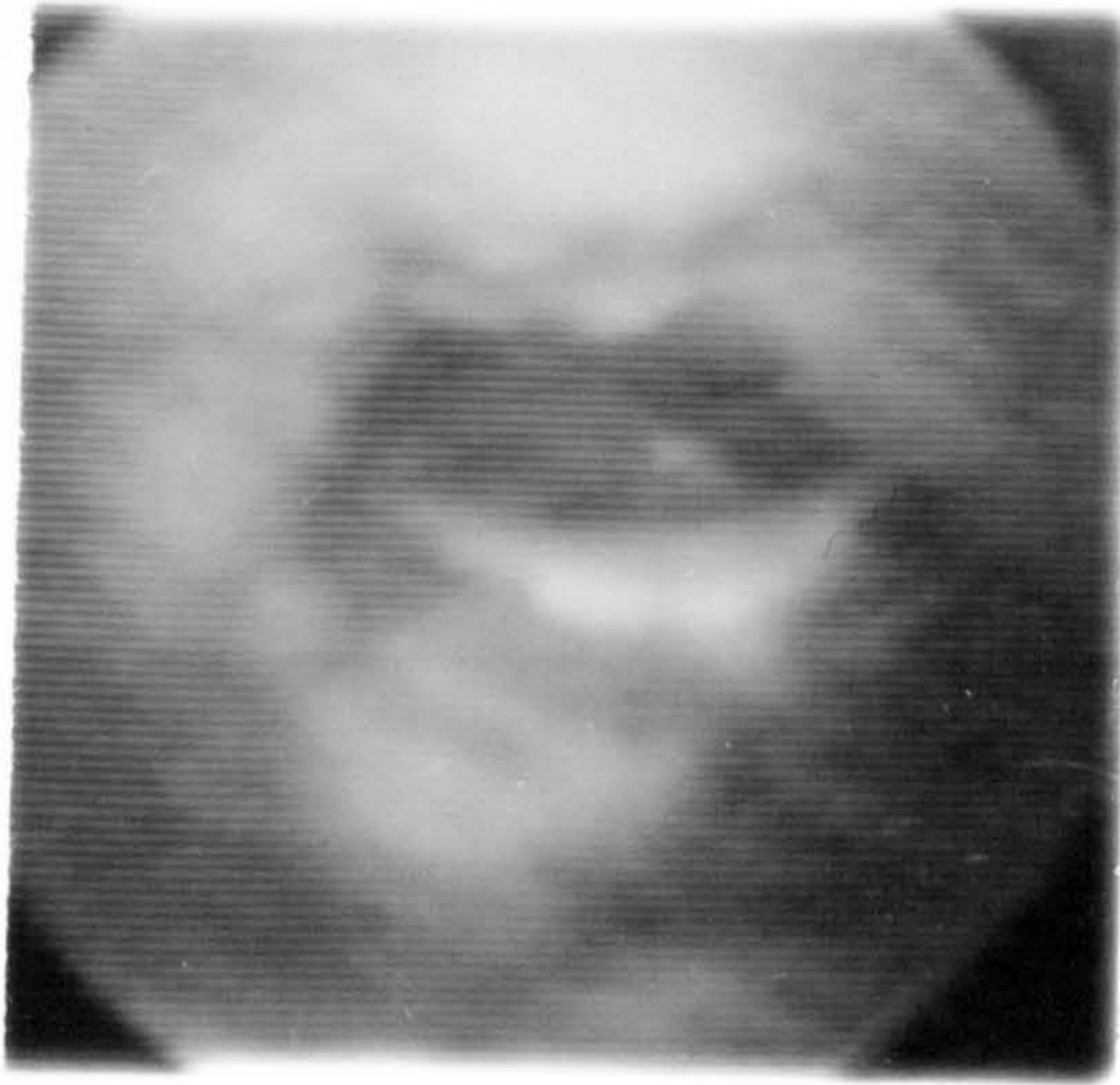
Sketches of Figure 5.10

see a movement of the tongue root.

Examples of /X/ Figure 5.10.b and of /g/, Figures 5.11.a and b of these sounds said in isolation by FL show a considerable resemblance to the articulation observed for /q/ and the pharyngealized sounds, a constriction in the whole pharynx manifested in a) an inward movement of the lateral wall of the pharynx and b) a constriction in the vallecula area by the root of the tongue pressing the epiglottis and uncurling its tip.

Airflow analysis

The aerogram of /gaxx/, Figure 5.12 of subject FL. It is not unusual to have short periods of nasal flow immediately after inspiration and before speech starts even while there is oral closure. Oral flow here is minimal at the beginning of voicing for /g/, while nasal flow continues on at about 50 ml/s and only reduces to zero 80 ms later. Though this nasal flow is quite small, it is difficult not to describe this initial consonant as nasalized. As the pressure increases for /x/, the soft palate closure tightens and nasal flow reduces to zero. Note how larynx (IX) rises with fronting of the tongue.



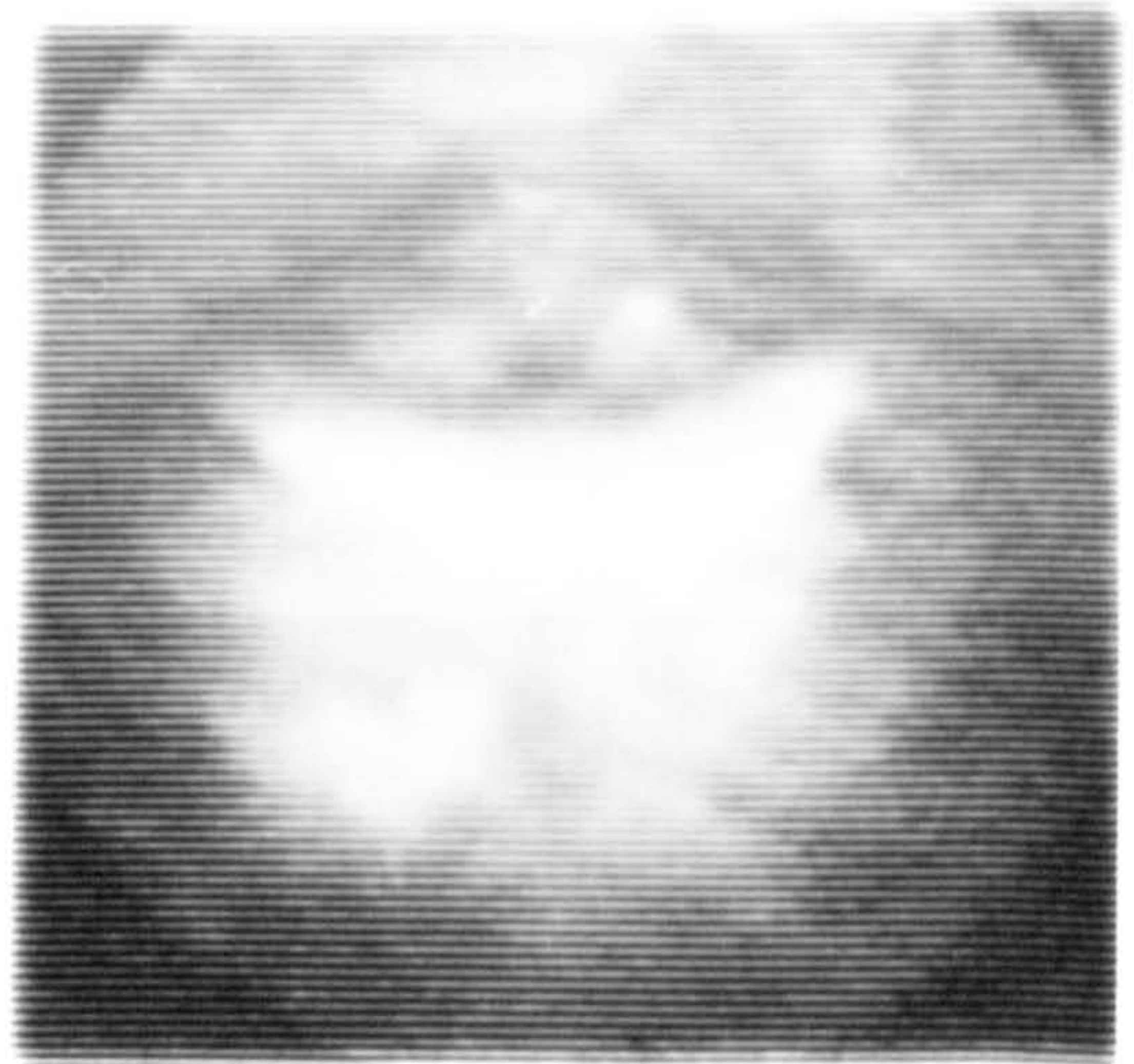
a. /g/ (FL)



b. /g/ (FL)

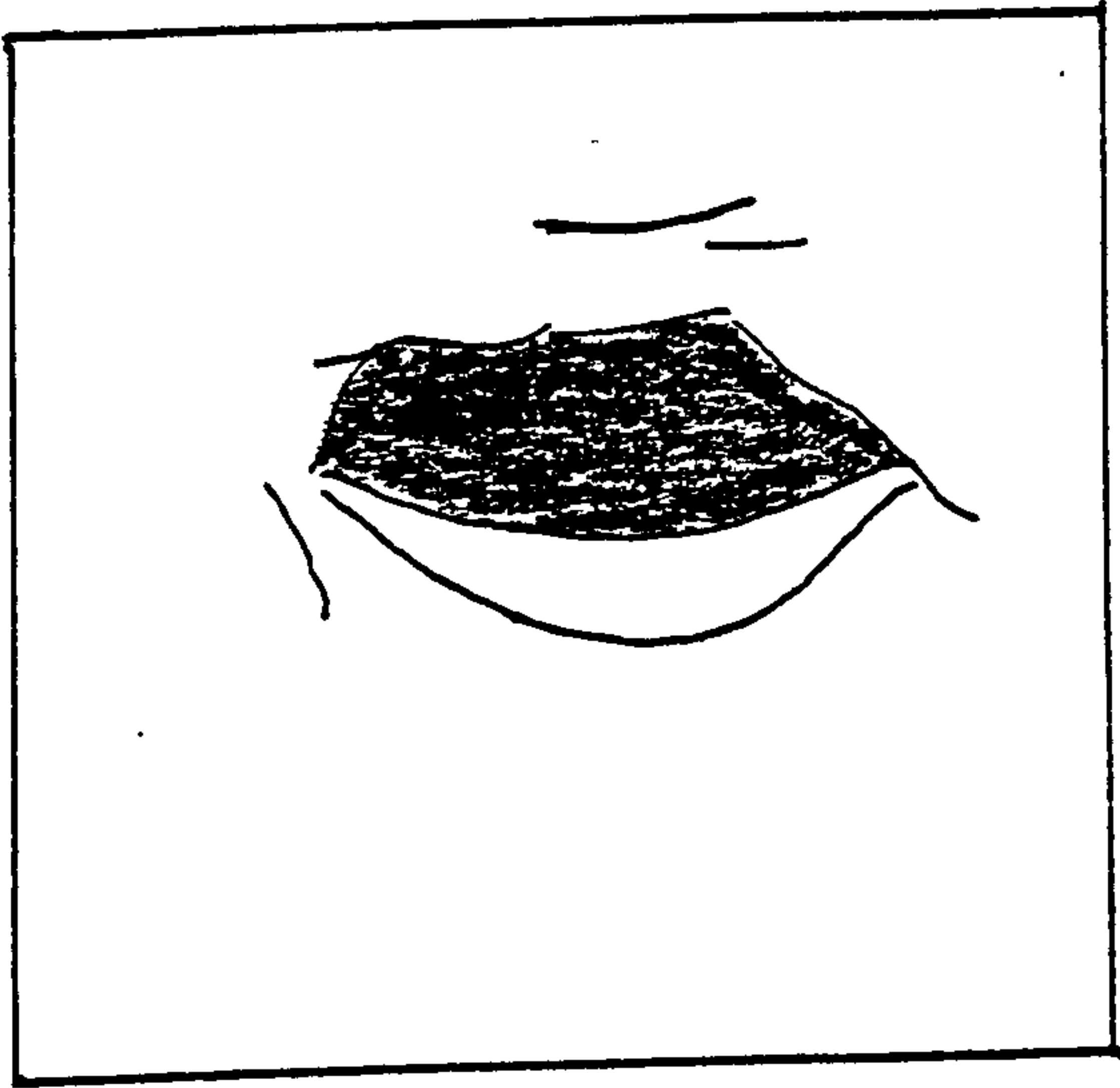


c. /g/ in /gæsp/ (FL)

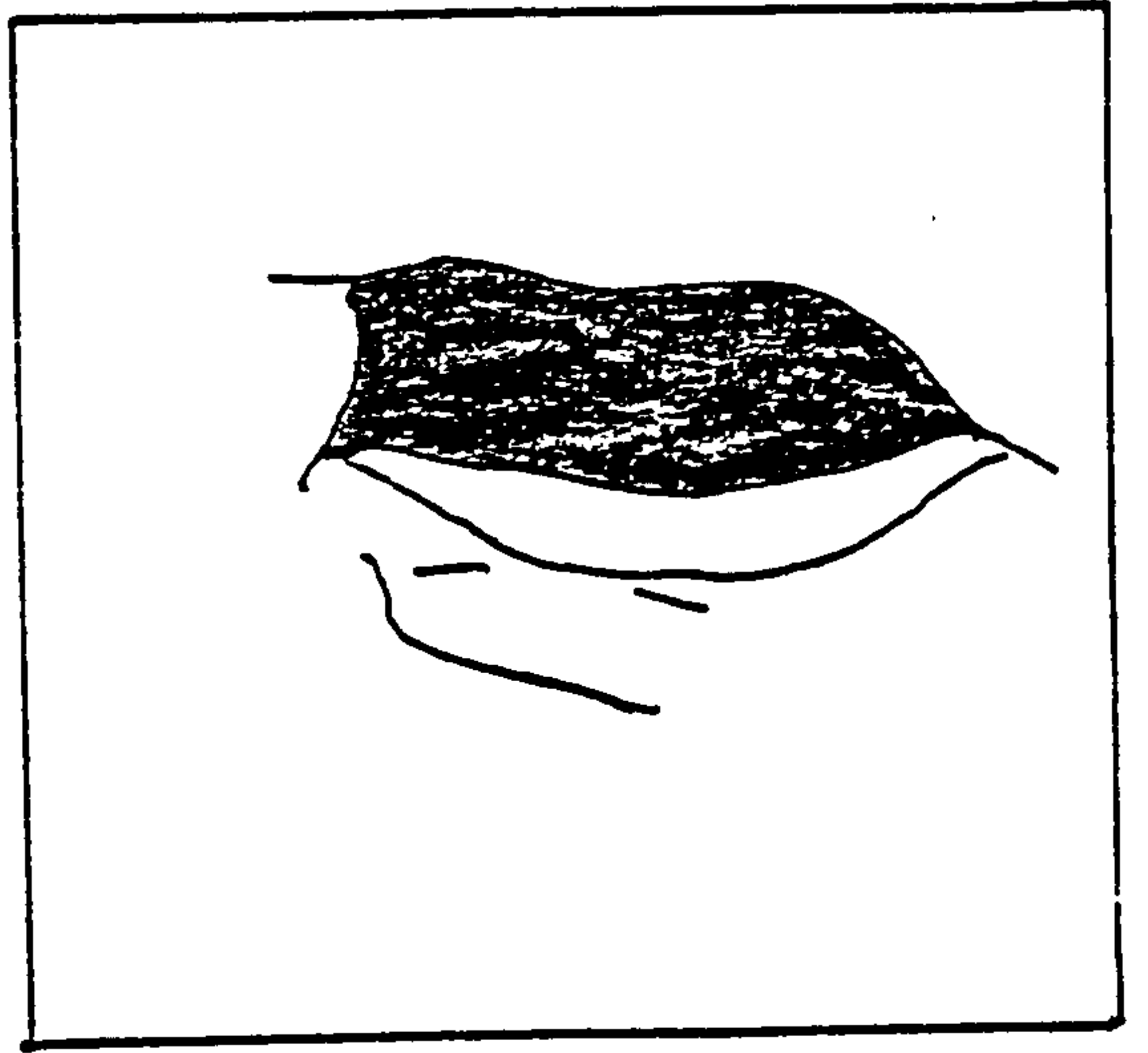


d. /g/ in /ga:di/ (FL)

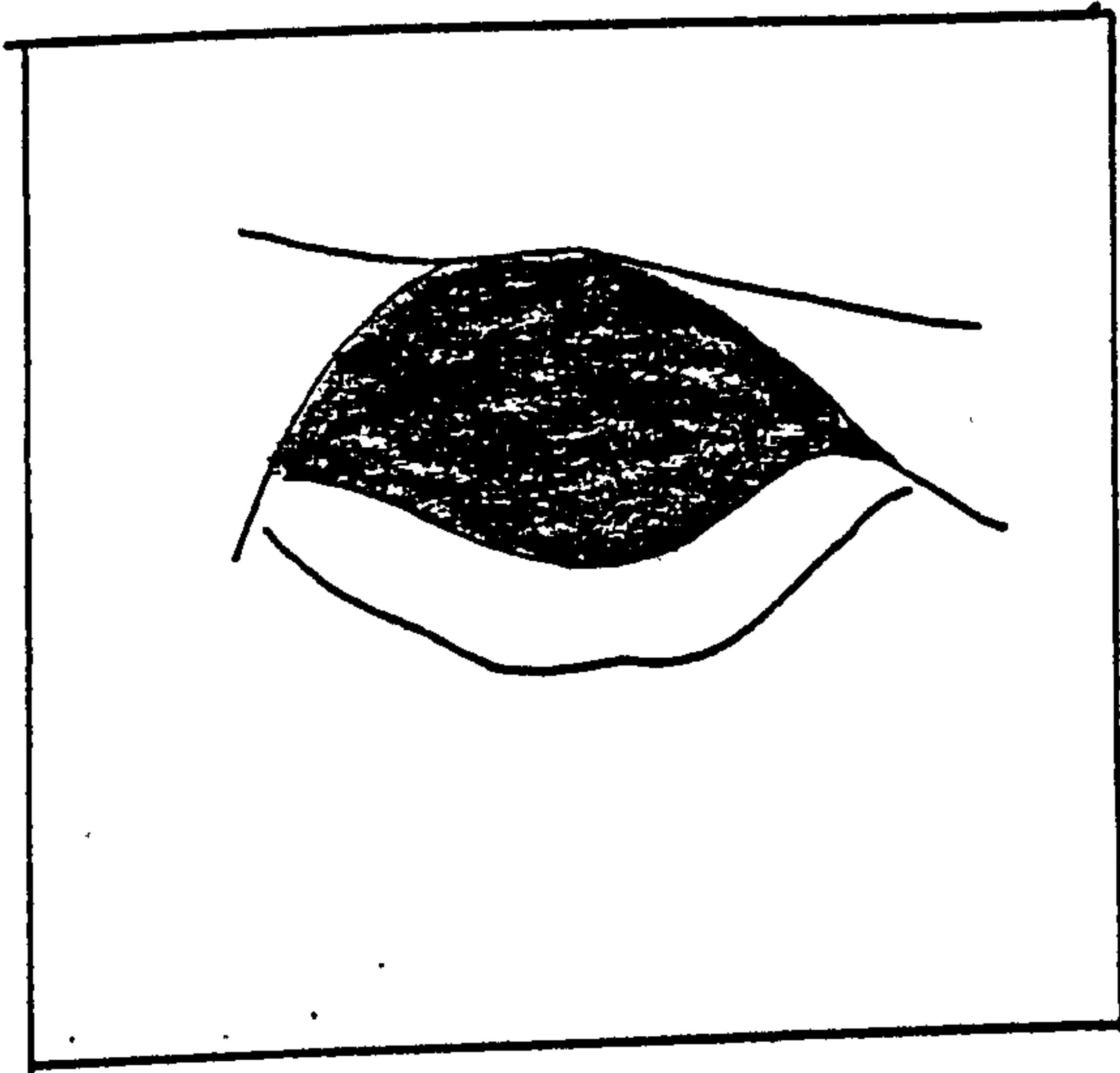
Figure 5.11



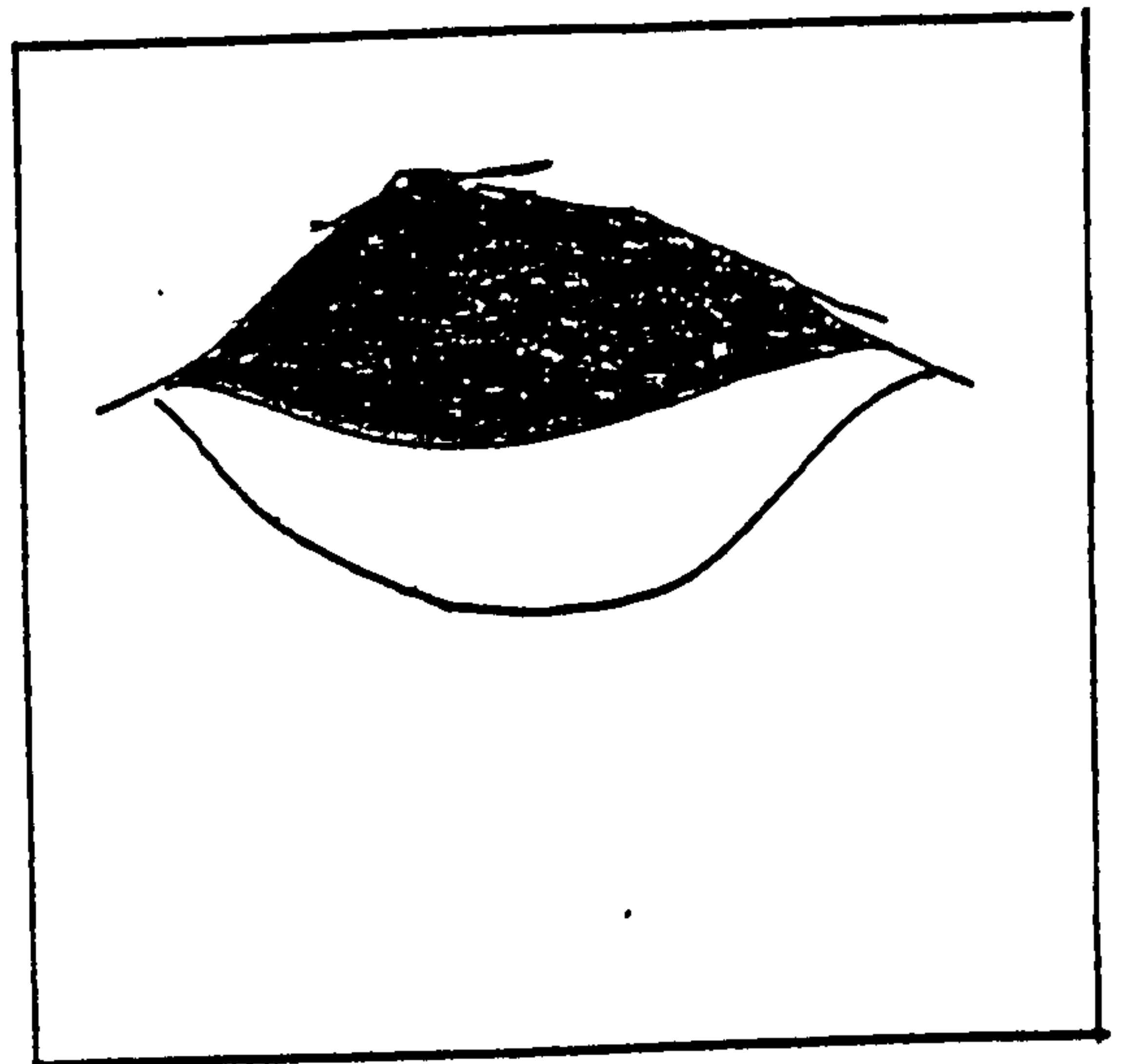
a.



b.



c.



d.

Sketches of Figure 5.11

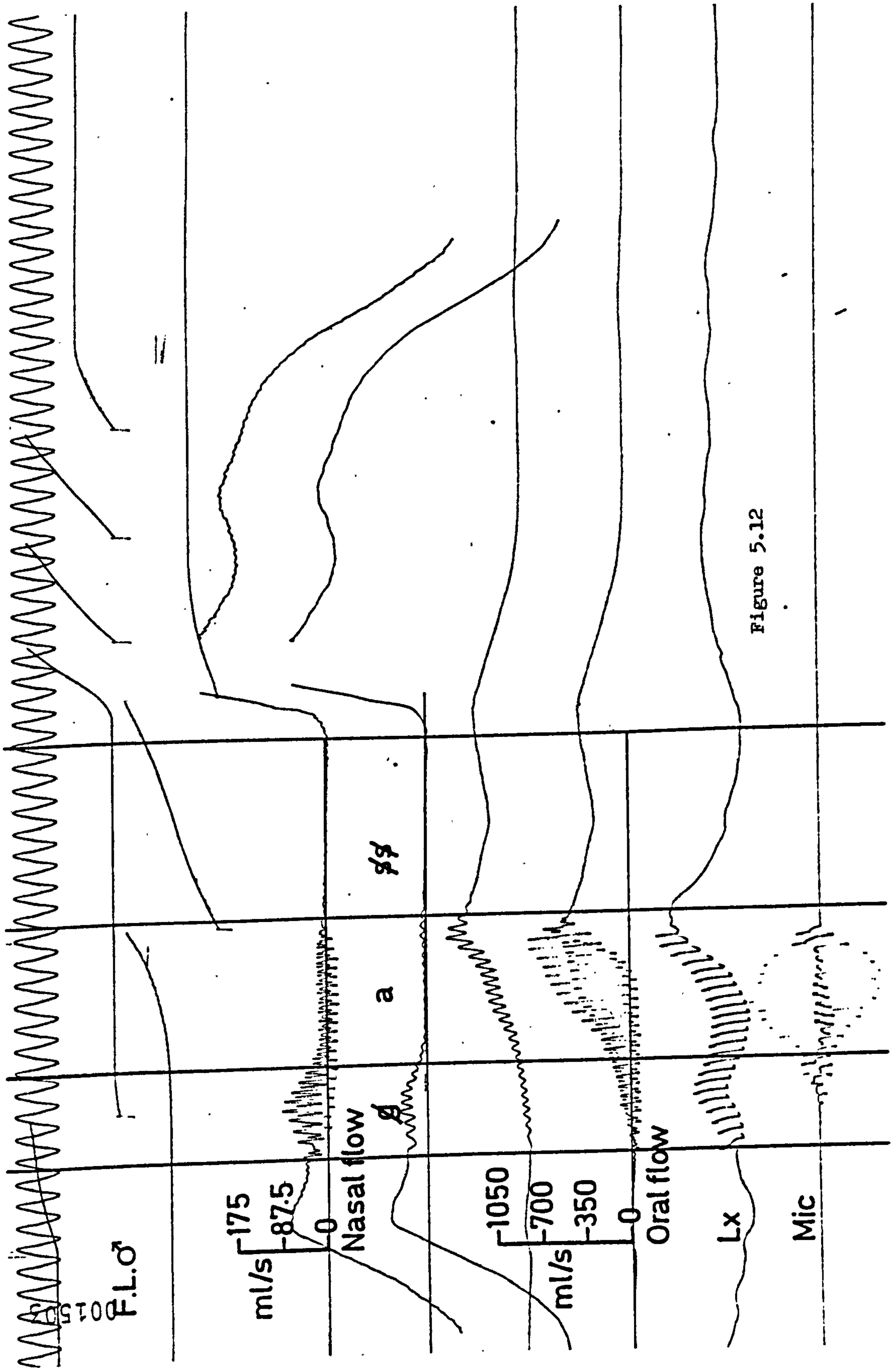


Figure 5.12

In /Xaʒʒ/, of subject (WL), Figure 5.13, expiration through the mouth follows smoothly on from inspiration reaching about 700 ml/s before the trace shows evidence of turbulent flow. /X/ begins probably 150 ms before voicing starts and /ʒ/ probably lasts about the same time after voicing has ended. Peak flow for /X/ is more than 1100 ml/s, and for /ʒ/ about 1000 ml/s. There is no nasal flow throughout the utterance.

In /nuXXa:la/, for instance, as said by WL, the amplitude of the high frequency components of the turbulent airstream is limited by the frequency response of the oscillographic system, but the noisy random oscillation of the trace is characteristic of fricative noise. One would suppose that the main source of this fricative noise is the larynx, and is caused by close approximation of the vocal cords with further friction, as an extra added modulation, produced by the root of the tongue approaching the uvula closely. This modulation occurs only for the segment /X/. In all the traces of /X/, the flow through the nose reduces to a very small value or zero, an indication of the closure of the velopharyngeal orifice.

The nasal flow for the initial segment /n/ continues over the following two segments /u/ and /XX/.

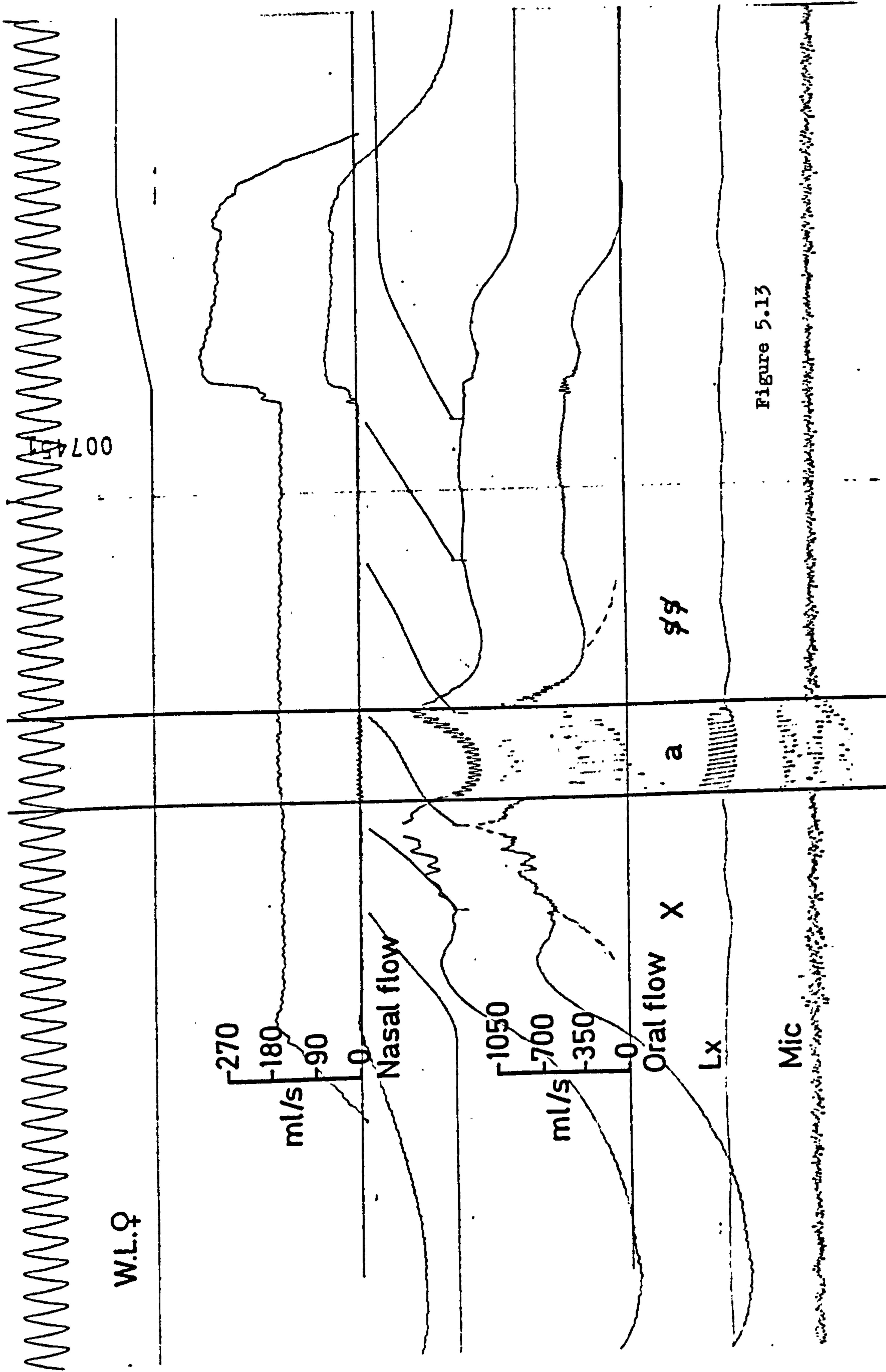


Figure 5.13

CHAPTER VIThe Pharyngealized Consonants

Lehn (1963:30), defines 'emphasis' "by the occurrence of the first and one or more others of the following articulatory features: (1) slight retraction, lateral spreading and concavity of the tongue and raising of its back, (2) faucal and pharyngeal constriction, (3) slight lip protrusion or rounding, and (4) increased tension of the entire oral and pharyngeal musculature resulting in the emphatics being noticeably more fortis than the plain segments". Mitchell (1956:6), applies the term emphatics to 'ṣ, ẓ, ṭ and ḍ' to distinguish them from s, z, t, and d respectively. He says that "For all the emphatics, the tongue must be broad and 'thick' filling the mouth: for s, z, t, and d, on the other hand, the tongue is narrow and 'thin'". There is a lateral contraction and expansion of the tongue, at the same time, the front of the tongue is very much lower in the mouth for the 'emphatics'. There is a contact of the tongue at the teeth or junction of teeth and gums. The tongue is hollowed from front to rear. For the 'emphatics', the lips are held neutral or slightly rounded and protruded; for s, z, t and d, they are spread. "These factors combine in the emphatics to produce a characteristically 'hollow' resonance". (Mitchell, 1956).

Obrecht, (1970:230-31), states that "the pharyngealized /t/, as with other pharyngealized consonants, is customarily articulated with tongue back and pharyngeal constriction, the point of articulation being the same as for /t/ or slightly behind it".

Catford, (1977:193), says that "Pharyngealized sounds involve some degree of contraction of the pharynx either by a retraction of the root of the tongue, or by lateral compression of the faucal pillars and some raising of the larynx, or a combination of these". He later (1981), points out that pharyngealized articulation occurs in a number of Caucasian languages, with two places of articulation, primary at the lips or uvula, and secondarily, in the pharynx. In these languages, pharyngealization and labialization occur on the same sound. He also points out that in these languages, full sets of plain and pharyngealized vowels occur where the front vowels seem to be lowered and retracted, and the back ones fronted. He draws on the similarity between them and the American

/r/, where in both cases, the tongue root bulges towards the back wall of the pharynx at the level of the epiglottis, while a depression is found in the dorsal surface of the tongue, approximately opposite the uvula, with another bulge further up and forward on the tongue. He calls it 'double bunching'. He draws attention to the similarities in X-ray tracings of these sounds and those

of Delattre and Freeman (1968), and Ladefoged's (1979) of the American /r/.

The phonological analysis of the pharyngealized consonants took several forms of which some were described in Lehn (1963). Arab grammarians defined these consonants as 'mufaXXama' and the phenomenon as 'tafXiim' and besides /T/, /D/ and /S/, they recognized /r/ as pharyngealized in certain environments, that is, when /r/ occurs adjacent to the vowels /a/ or /u/, and the pharyngealized consonants (including the uvulars /X/, /g/ and /q/). These, in turn, however, have to be adjacent to /a/ or /u/. /r/ cannot be pharyngealized if it is adjacent to /i/, except with /X, g and q/, in which case /r/ may be pronounced as pharyngealized. The traditional analysis by European linguists, only recognized those consonants that are represented in the Arabic orthography — /T, D. Ø, S/ and called them 'emphatics' and the phenomenon 'emphasis'. In Egyptian Arabic, Willmore (1905), Gairdner, (1925), Mitchell, (1963), cited the consonants /T, D, S, Z/ with a reference to an 'emphatic' /L/, namely in the name of god /ʔalla/ or its derivatives.

Based on the above treatments, all the consonants can be phonemically pharyngealized and non-pharyngealized with the vowels being retracted in the environment of the pharyngealized consonants. In spite of its appeal to the investigator, because it solves the problem of which consonant to consider

as phonemically pharyngealized, it is not practical, because it increases the number of the consonantal phonemes of the language.

Another approach is to treat the vowels as phonemically pharyngealized, all the consonants in the environment becoming consequently pharyngealized allophones. This analysis would seem to solve the problem of which consonants are phonemically pharyngealized. That is, the vowel /a:/, for instance, would be recognized allophonically as pharyngealized and /a:/ as its non-pharyngealized counterpart. However, this analysis cannot be applied to TA, because it cannot account for the distinction in the following examples where the three words have distinctive meanings.

/da:r/ 'he did', /da:r/ 'room', /Da:r/ 'harmful'.

Moreover, it increases the number of the vowel phonemes.

The supra-segmental analysis was originally suggested by Ferguson, (1956), and taken up by Harrell (1957), whose reasons for preferring this analysis are a) it is a long component which never occurs as a feature of a single segment, its minimum domain being 'V(:)C or CV(:)', b) 'it is a gradient feature'. (c) it is a stylistic feature. The last two can be related to the variations that exist in the speech of men and women, which will be referred to in chapter 7.

Also the prosodic analysis, Maamouri, 1967, and Gaber 1972, and the focal point analysis, Odisho, 1973, and Ahmed 1979, where in the latter 'emphasis' reaches its maximum realization in the focal point. All these approaches, including the supra-segmental treat 'emphasis' as a function of the entire syllable. Its minimum domain being part syllable. Its domain is, however, governed by the number of focal points; to whether the focal point is in initial, medial or final positions, and to the consonants and vowels adjacent to it.

6.1 The primary pharyngealized consonants

Unlike the pharyngeals and, to a lesser extent, the uvulars, the number of these consonants varies from one dialect to another in relation to Classical Arabic. Early Arab grammarians recognized the consonants /T/, /ð/* and /S/ as 'muTbaqa' with a spreading and raising of the dorsum or 'mufaXXama', that is, auditorily, 'thick' or 'heavy'. Anis (1961), assumes that the /T/ described by the early Arab grammarians was similar to present day /D/, whereas, /ð/ was probably what is heard nowadays in, for instance, Iraq.

/T/ was a feature of the dialect of Quarish, which due to its difficulty to produce by the Arabs of the other

* /ð/ a voiced pharyngealized denti alveolar fricative.

/d/ a voiced non-pharyngealized denti-alveolar fricative.

tribes and the peoples of the non-Arab countries, was later developed into either /D/ or /ð/.

Present day /T/ was not known in those days.

This is supported by the way /T/ is pronounced nowadays in Yemen and by Bedouins, Anis (1961), and Matar (1981). This agrees with Sibawaih's statement that if it had not been for 'iTba:q' /T/, /ð/, /S/ would have become /d/, /ð/ and /s/ respectively and /D/ would have been omitted. That is, early Arab grammarians considered /T/ as a pharyngealized /d/. In other words, what the Arab grammarians described as /T/ is actually what is pronounced nowadays as /D/.

In Chapter 4, it was seen how views varied with regard to the allophones of /ʕ/ in some Arabic dialects, mainly Eastern and Sudanese. Here the matter is directed mainly to what constitutes the 'true' pharyngealized consonants. As mentioned, the four consonants /T, D, ð, S/ form the basis of the pharyngealized consonants. This was apparently influenced by Arabic orthography, which has special letters for these consonants. These basic consonants vary from one dialect to another, where in Iraqi and possibly Eastern Arabic /ð/ is used instead of /D/. This is possibly the case for some dialects of Libyan Arabic, but not TA, whereas in some other Arabic dialects (including TA) /ð/ is dropped and /D/ or /Z/ are used instead, for instance, in /Za:b:it/ or /Da:bit/ 'officer'.

In TA, the 'true' or primary pharyngealized consonants are /T, D, S, Z, L/ to be distinguished from their non-pharyngealized counterparts /tdszl/. /L/ differs from /TDSZ/ in three respects, a) it only occurs in the name of god and its derivatives, b) it occurs adjacent to the open vowel /a/ or /a:/ in /waLLa/, /?aLLa/ or /waLLa:hi/ and c) it is not represented in the Arabic orthography with a special letter. Experimental evidence of the articulation of /L/, and moreover, the kinesthetic feeling of the author as a native speaker, are strong reasons to justify treating it as a primary pharyngealized consonant with /TDSZ/. Mitchell (1957), while objecting to the use of the term 'pharyngealization', instead of 'emphasis', says that "... (pharyngealization) is a feature with which it is perfectly possible to imbue one's speech passim, as with, say, 'a nasal twang', so that a properly pharyngealized 'L' is greatly different from the 'emphatic' 'L' of e.g., 'allaah' (god) in Arabic". Ignoring the matter of which term used, Mitchell is right in making this distinction. As will be discussed later, there is a difference, for instance, in the two laterals in /?aLLa/, and /la:mba/, where the first is a pharyngealized, or according to Mitchell, 'emphatic' /L/, and the one in /la:mba/ is not pharyngealized in the sense that its slight retraction is probably a result of the vowel /a:/.

6.2 The secondary pharyngealized consonants

The number of the 'secondary' pharyngealized consonants varies from one analysis to another, though most seem to recognize the consonants /l, r, q/ as pharyngealized. Krieg, et. al., (1980), for instance, found that in Zilitin Arabic, pharyngealized counterparts of /X h / occur besides the basic ones. Others are more systematic in that they organize these consonants in three groups, Harrell (1957), Maamouri (1967) and Ahmed (1979), where the 'basic' consonants are called primary. This is also restricted to whether the consonants occur in the dialect or not. Harrell and Ahmed, for instance, cite /T, D, S, Z/ for Egyptian Arabic. Maamouri, on the other hand, cites /t̤, s̤ and ʕ/ for Tunisian Arabic. They define the rest of the consonants as secondary, and marginal. Harrell, for instance, divides the secondary 'emphatics' into 'conjunct secondary emphatics', which are coterminous with the primary, that is, their occurrence is governed by the presence of a primary 'emphatic' where the rules of the primary 'emphatics' apply. Their distribution is not limited, but may occur with any vowel. The other kind he calls 'independent secondary emphatic', which are rare and limited in distribution, because they occur in words which have no primary 'emphatic' consonants. Harrell's reason for grouping some consonants under 'marginal

'emphatics' is the difficulty to find satisfactory examples to show that there is a direct contrast between 'emphatic' and 'non-emphatic' consonants. The only 'independent' examples he found were a consequence of the occurrence of secondary 'emphatics' or 'stylistic emphasised pronunciation'. There is no real difference, however, between the secondary and the marginal pharyngealized consonants in those studies. The frequency of occurrence of these consonants, though it varies from one to another with /R/ being more frequent, are all dependent in their occurrence on the presence of a) the open vowel /a/, and b) a primary pharyngealized consonant. The best treatment of the pharyngealized consonants was posited by Ghazeli, (1977), where he describes the three consonants, /t̤, ʕ, s̤/ as pharyngealized as they occur in his speech and others he defines sceptically as pseudo-pharyngealized. He rejects treating the latter as pharyngealized simply because they occur with /a/, because they do not occur with 'palatal' vowels and because they do not induce the retraction of the adjacent segments. His treatment of the consonants /q/ and /r/ is interesting and acceptable. The problem is present in TA as well, and, as he suggests, it may be peculiar to North African dialects, though the author is certain that this occurs in other dialects as well, where a phonemic-split of /a/ 'occurred', for instance, in Cairene and North Lebanese Arabic (Ferguson, 1956).

The problems inherent in such a choice, will be apparent below. Thus, the minimal pairs to prove that /a:/ exists can be given:

/na:r/	'it was lit'/na:r/ 'fire'
/ma:r/	'common' /ma:r/ 'passing'
/ʒa:ri/	'liquid' /ʒa:ri/ 'my neighbour'
/ʎa:r/	'he was puzzled' /ʎa:r/ 'hot/spicy'

It may be argued that as they all occur with the consonant /r/, /a:/ in the second group should be treated as allophones of /a:/, which were retracted under the influence of /r/ assuming that /r/ is pharyngealized. This may be accepted, but only reluctantly, because even without experimental evidence, as a native speaker, one cannot wholly accept it as a pharyngealized /R/. This becomes apparent when another word with a primary pharyngealized consonant occurs in /Da:r/. It is plausible to accept the phonemic split even though only one example can be cited. Thus, the three words can be given with clearly distinctive meanings:

/da:r/ 'he did', /da:r/ 'room', /Da:r/ 'harmful'.

No examples of /t/ or /s/ can be found except as pharyngealized/non-pharyngealized as in:

/ta:r/ 'he rebelled/revenge', /Ta:r/ 'he/it flew'
 /sa:r/ 'he walked' /Sa:r/ 'it (ms. sg.) happened'

A distinction is sometimes made between /sa:r/ 'he walked' and /sa:r/ 'happy, but this is not significant, and probably only a stylistic variant very likely occurring as an influence of Egyptian Arabic in the case of /sa:r/.

In TA, no considerable difference can be detected articulatorily in the pronunciation of /r/ in /barri/ 'go' (fem. sg.), and /birri/ 'bedouin/, though one is preceded by an open vowel /a/ and the other by a close front vowel /i/. This could be due to /r/ retaining its identity when it is geminated, regardless of the adjacent vowels. Harrell (1957), cites the examples /barri/ and /barri/ where, in the second case, /r/ is pharyngealized. He found that /i/ is less centralized when /r/ is not geminated in /ri/ than in /rri/.

Videoflorographic analysis did not show any obvious differences in the articulation of /i/ in /ʒa:ri/ and /ʒa:ri/, (Figures 6.16.a.b); though one is preceded by /a:/ and the other by /a:/. It is possible, of course, that a syllable division may be behind this lack of retraction for /r/ in /ʒa:ri/.

Endoscopic evidence showed that /r/ has an articulatory configuration more similar to the uvular /q/ and the vowel /a:/, than the pharyngealized consonants.

The pharyngealized effect in words with /r/ and the open vowel /a:/ is best treated in terms of the vowel and not /r/. This becomes evident when minimal pairs with /a:/ and /a:/ without /r/ are cited.

/ʔama:n/ 'safety' /ʔama:n/ 'a word of exclamation'

/ba:ni/ 'he has built' /ba:ni/ 'a proper name'

/b/ and /g/ also occur with /a:/ in /gubga:b/ 'wooden clogs', /ga:b/ 'he has bumped into'.

Lehn (1963), cites minimal or near minimal pairs of /ħ/ and /ʕ/ as 'emphatic', 'non-emphatic' in Cairene Arabic. According to the above analysis, one is inclined to attribute the 'emphasis' in Lehn's examples to the vowel. This is why, for instance, the following words are thus transcribed:

/ħa:r/ 'he puzzled, /ħa:r/ 'hot'.

In the light of the above discussion, the primary pharyngealized consonants /TDSZL/ are characterized by certain articulatory and acoustic features which are manifested in the adjacent vowels and consonants. Accordingly, these adjacent consonants are considered secondary pharyngealized consonants. That is, the secondary pharyngealized consonants only occur in the environment of the primary pharyngealized consonants, and mainly the open vowels /a:/ or /a/.

The pharyngealized consonants, in general, exhibit certain characteristics which are more or less attested by phoneticians and linguists. These characteristics can be given as follows:

Two points of articulation are the requisites for the production of these consonants. A primary one at the front part of the vocal tract made with the tip and blade of the tongue against the denti-alveolar region for /T/ and /D/, and the alveolar region for /S/, /Z/ and /L/. This point of articulation is little fronted for the non-pharyngealized counterparts, i.e., the primary articulation is the same for the pharyngealized and non-pharyngealized with only a slight retraction for the latter group. The secondary articulation is the one which characterizes /T/, /D/, /S/, /Z/ and /L/ as pharyngealized. According to Abercrombie, (1967:61), "...secondary, because the stricture referred to by place and manner in the classification of a segment is regarded as its primary articulation". He explains that "If the tongue is low in the mouth and retracted towards the back wall of the pharynx, the secondary articulation is one of pharyngealization", (1967:62). This secondary articulation "is a stricture of open approximation of the articulators, and as such involves less constriction of the vocal tract than the primary articulation does, whatever it may be". The secondary articulation is accomplished mainly by pushing the tongue backward

towards the rear wall of the pharynx. This is to be distinguished from the articulation of the pharyngeal consonants, where the root of the tongue is lowered and retracted. In the case of the pharyngealized consonants, there is no hump in the surface of the tongue like that for the pharyngeals. The tongue tends to flatten in the middle with a concavity in the front to accomplish the primary articulation which is more for /S/. Whereas, the tongue is almost convex and covers the molars and seems to fill the mouth for the non-pharyngealized counterparts, /t/, /d/, /s/, /z/ and /l/. This is not unexpected, as the backward movement pulls the back of the tongue - while the front of the tongue tries to hold the same front position, resulting in a narrowing, removing it from the teeth, and creating a groove in the centre.

The movement backward of the tongue is accompanied by a muscular tension felt to be concentrated mainly at the back of the tongue. MacCurtain (1982), suggests that the styloglossus muscle may be one of the dominant muscles that produce this configuration of the back and the root of the tongue.

A change in the configuration of the vocal tract can result during the production of the pharyngealized consonants. The front part of the vocal tract behind the primary constriction widens whether the back of the tongue is raised or lowered, depending on the adjacent vowels. The pharyngeal cavity narrows with a considerable constrict-

tion at about the level of C2. Though this place of constriction lies at a higher level than that for the pharyngeals, the force exerted on the epiglottis by the lowered and retracted movement of the tongue, presses its whole length down and uncurls its tip without pushing it back. This action alters the configuration of the laryngopharyngeal cavity, which, in certain cases, even widens as is shown in the lateral xeroradiogram of /T/ in /Ti:n/, (MacCurtain 1982).

Studies of pharyngealized consonants mostly include the feature of lip rounding and/or protrusion, Blanc (1953), Mitchell (1956, 1975), Jakobson (1957), Harrell (1957), Lehn (1963). Odisho (1973), found that only slight rounding and protrusion occur for Iraqi Arabic of Baghdad. Mitchell (cited in Odisho), observed a large degree of lip rounding and protrusion during the articulation of the pharyngealized consonants by some Bedouin of Libya. Investigation of this feature in TA and from labiographic evidence, show that slight lip protrusion occurs only when the adjacent vowels are /u/ and /u:/, and less so when that vowel is /o:/.

Ghazeli (1977), found that slight protrusion of the lower lip of 2 to 3 mm occurred for /s/, and /t/ relative to /s/ and /t/, but he speculatively attributes this to either a) coarticulatory factors and anticipatory

gesture for the following vowel, or b) the horizontal distortion during tracing which showed an enlargement of 2.5 percent occurring at the anterior (lips) part of the radiographic field.

Odisho, (1973:43-44), observed a slightly greater lowering of the jaw for these consonants, especially stops which he attributes to "the sudden release of the closure and forceful depression of the tongue".

Another articulatory feature observed is that of displacement of the hyoid bone. Marçais (1948), tracings of the 'emphatic' consonants, clearly show this feature in various degrees with a considerable raising for /D/ relative to /d/ and to the other pharyngealized consonants with the minimum raising for /R/. In TA, a slight upward movement of the hyoid bone is observed to occur for the pharyngealized consonants. Ghazeli (1977), did not observe any apparent major displacement of the hyoid bone for the pharyngealized consonants. He found that the hyoid bone was generally moved slightly back for the pharyngealized consonants. He suggests that this may be due to the backward movement of the tongue. He observed a higher position of the hyoid bone (2 mm) only in the articulation of /t/ followed by the consonant /b/. He found no differences in the upward displacement of the hyoid bone between /s/ and /s/ .

The physiological change resulting from the constriction of the pharynx by the backward movement of the tongue and a lateral movement of the side walls of the pharynx, undoubtedly has an acoustic effect which has been long attested to for various dialects of Arabic. Obrecht's study using speech synthesis, of velarization in Arabic (1968), indicates that F2 is the most important cue for perceptual identification of a pharyngealized consonant. Coady (1967), in his study of 'emphasis' in Egyptian, Iraqi, Saudi Arabian and Tunisian Arabic found that "acoustically, emphasis may be defined as a lowering of the second formant, either in part or in full". On the other hand, Shaheen (1979), in his extensive acoustic study of the consonants in Egyptian Arabic concluded that "The phenomenon of pharyngealization in Arabic is, in fact, a good example for illustrating the fallacy of correlating F2-transition too readily with articulatory place of production. In the case of the non-pharyngealized consonant /d/, F2 transitions of adjacent vowels point to a locus frequency of about 1800 HZ. In the case of the pharyngealized consonant /d/, by contrast, F2 transitions of the adjacent vowels point to a much lower locus frequency at about 1200 H2. Yet, in spite of this extensive displacement in the direction of F2-transition, the fact still remains that both the pharyngealized and non-pharyngealized pair have approximately the same primary place of production".

Ghazeli (1977), found no apparent differences in the acoustic spectra of the voiceless pharyngealized/non-pharyngealized consonants /s/ and /s/. The configuration of the vocal tract for both these sounds is identical except that the tip of the tongue is slightly retracted for /s/ than for /s/, but this difference does not seem to have any obvious acoustic effect. He asserts the importance of the low F2 onsets of the vowels and the transitions of these vowels.

6.3 Results of experimentation See Appendix I for tables of results.

Xeroradiographic analysis

The geminated consonants /ll/ and /LL/ in /walla/ and /waLLa/ are shown in Figures 6.1 and 6.2. The narrowest constriction for /LL/ (5 mm) lies between a point on the dorsum of the tongue and the back wall of the pharynx at the level of the middle of C2. There is no constriction for /ll/ at this point, and the only constriction in the pharynx lies at the level of the epiglottis and C3 about 8 mm. This is narrower than the 'at rest' position and most probably a result of the adjacent vowel /a/. The dorsum and the front of the tongue are pushed forward to produce the non-pharyngealized /ll/. In /LL/ in /waLLa/, on the other hand, the dorsum and body of the tongue are retracted and raised towards the soft palate where a quite

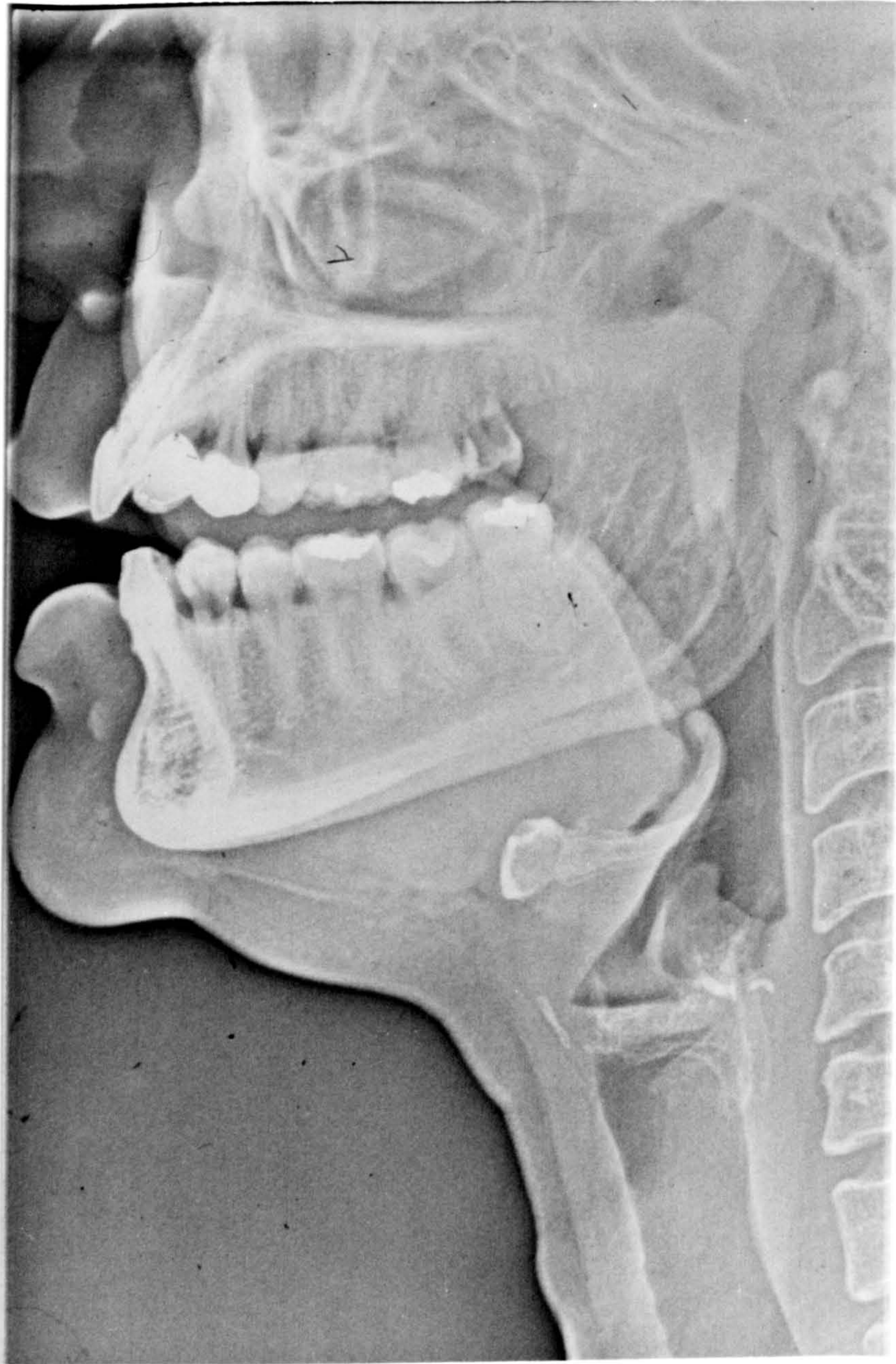


Figure 6.1 /11/ in /walla/ (WL)



Figure 6.2 /LL/ in
/waLLa/ (WL)

narrow constriction results between the tip of the soft palate and a point on the dorsum of the tongue, and, at the same time, the upper part of the soft palate is in contact with the back wall of the pharynx.

There is a narrow distance between the root of the tongue and the front face of the epiglottis for /ll/. This is almost non-existent for /LL/, due to the pressure exerted by the action of the retraction of the tongue against the back wall of the pharynx, though at a higher level. This results in depressing the epiglottis and uncurling its tip which results in a change in the cavity of the laryngopharynx, though not necessarily narrowing it. In /ll/, the body of the hyoid bone is lowered and the whole of the hyoid bone is pushed forward, whereas in /LL/, the body of the hyoid is slightly lowered, but the horns are raised to a level parallel to the upper surface of C3. This upward movement of the horns pulls it away from the back wall of the pharynx.

In the xeroradiograms of the vowel /i:/ in /ti:n/ and /Ti:n/, Figures 6.3 and 6.4 respectively, the similarities are very great. The constriction between the epiglottis and the back wall of the pharynx is greater for /ti:n/ than for /Ti:n/, 14 mm. as against 17 mm. However, for /i:/ in /Ti:n/, the constriction is narrower above the epiglottis than that for /ti:n/ with the narrowest constriction being between a point just above the epiglottis and

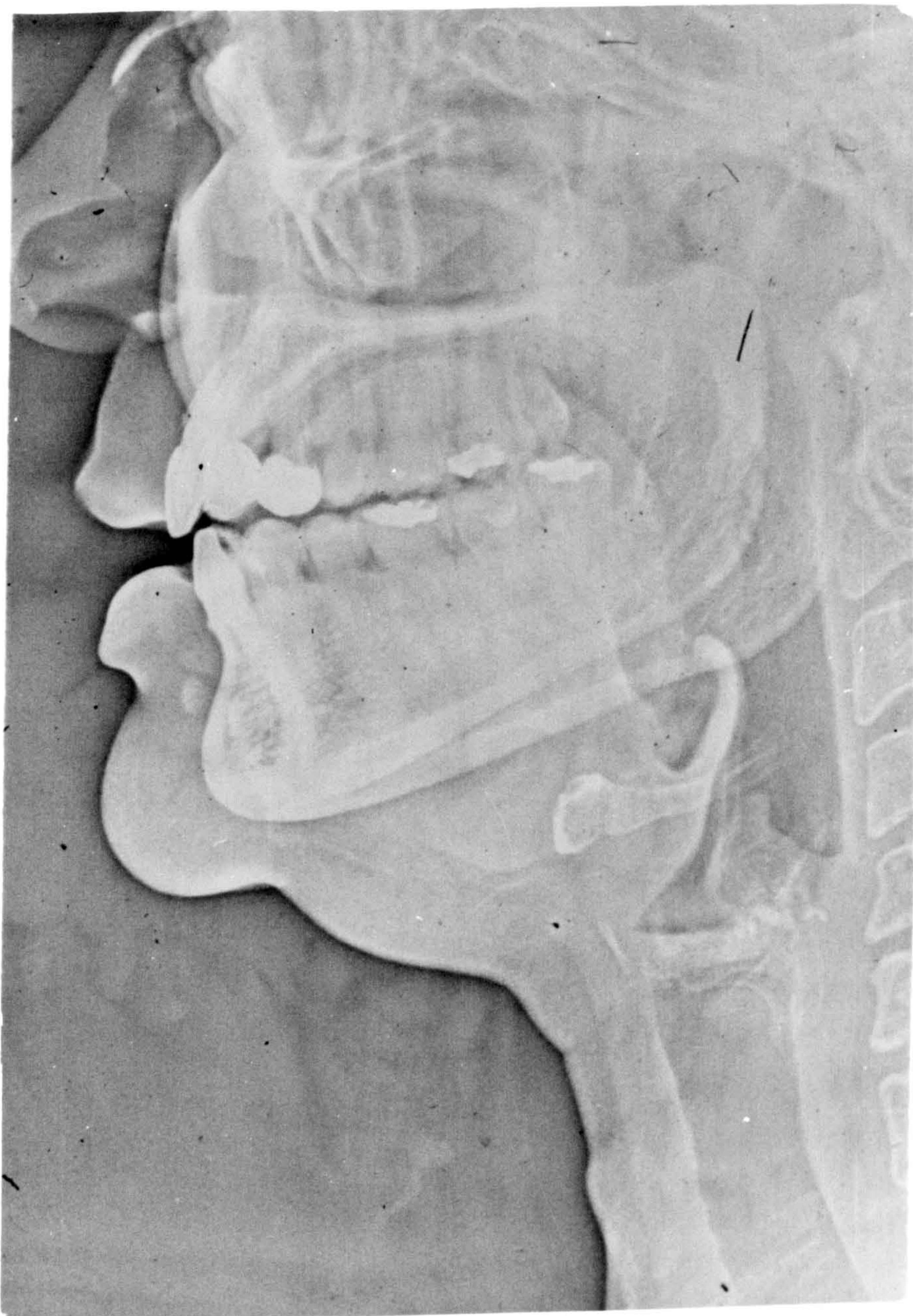


Figure 6.3 /i:/ in /ti:n/ (WL)



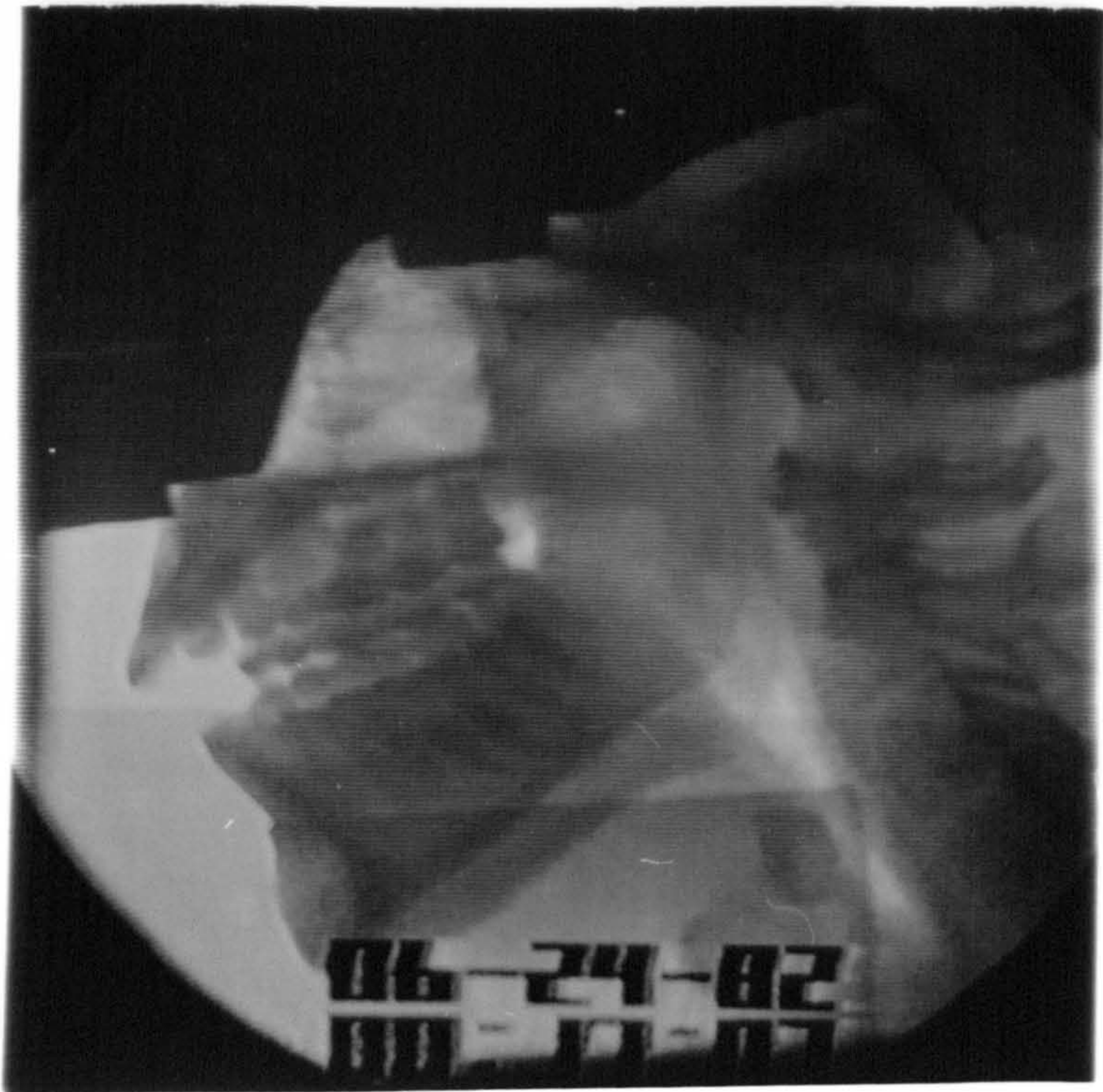
Figure 6.4 /i:/ in /Ti:n/ (WL)

the level of the bottom edge of C2. The distance between the root of the tongue and the front face of the epiglottis is wider for /ti:n/ than for /Ti:n/. This is because the epiglottis, pulled by the tongue for the articulation of the front vowel /i:/, does not go as far forward as it does for the pharyngealized /Ti:n/, a rather unexpected action. The front of the tongue is slightly retracted for /Ti:n/ than for /ti:n/. The larynx and the hyoid bone are slightly raised for /Ti:n/.

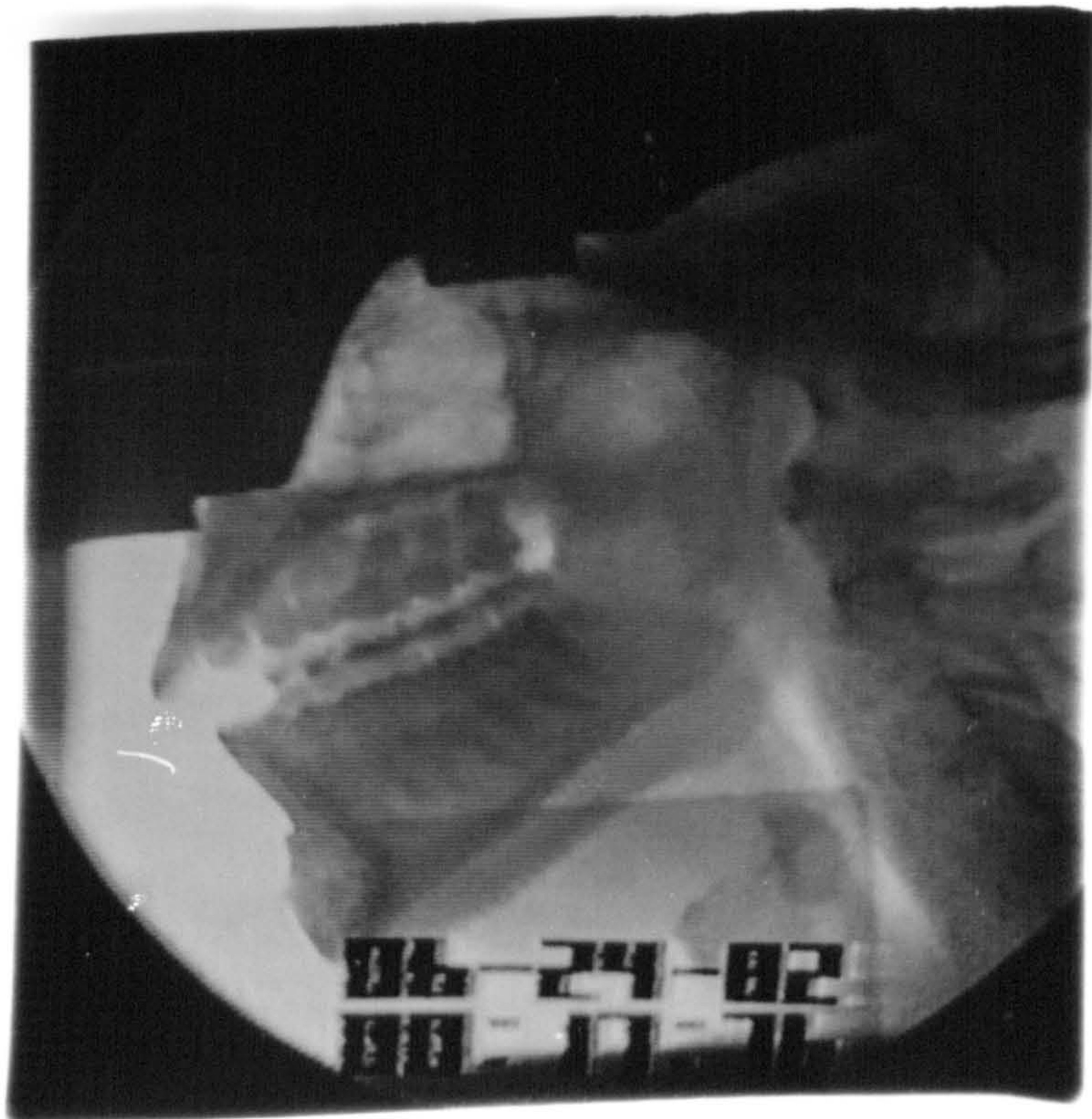
In the above four examples, the soft palate is in contact with the Passavants ridge. The shape of the soft palate is quite similar in all these examples. No significant variation is shown in the lip position or shape between the pharyngealized and non-pharyngealized consonants or adjacent vowels.

Videofluorographic analysis

Figure 6.5.a and b show /t/ in /ta:b/ and /T/ in /Ta:b/ respectively. As will be seen in the other examples of pharyngealized consonants, /Ta:b/ shows the narrowest pharyngeal constriction in relation to the other examples. This is undoubtedly due to the presence of the low vowel /a:/ in the word which has a very similar constriction to that for a pharyngeal consonant, that is a very low place of constriction at the level of the epiglottis. Because



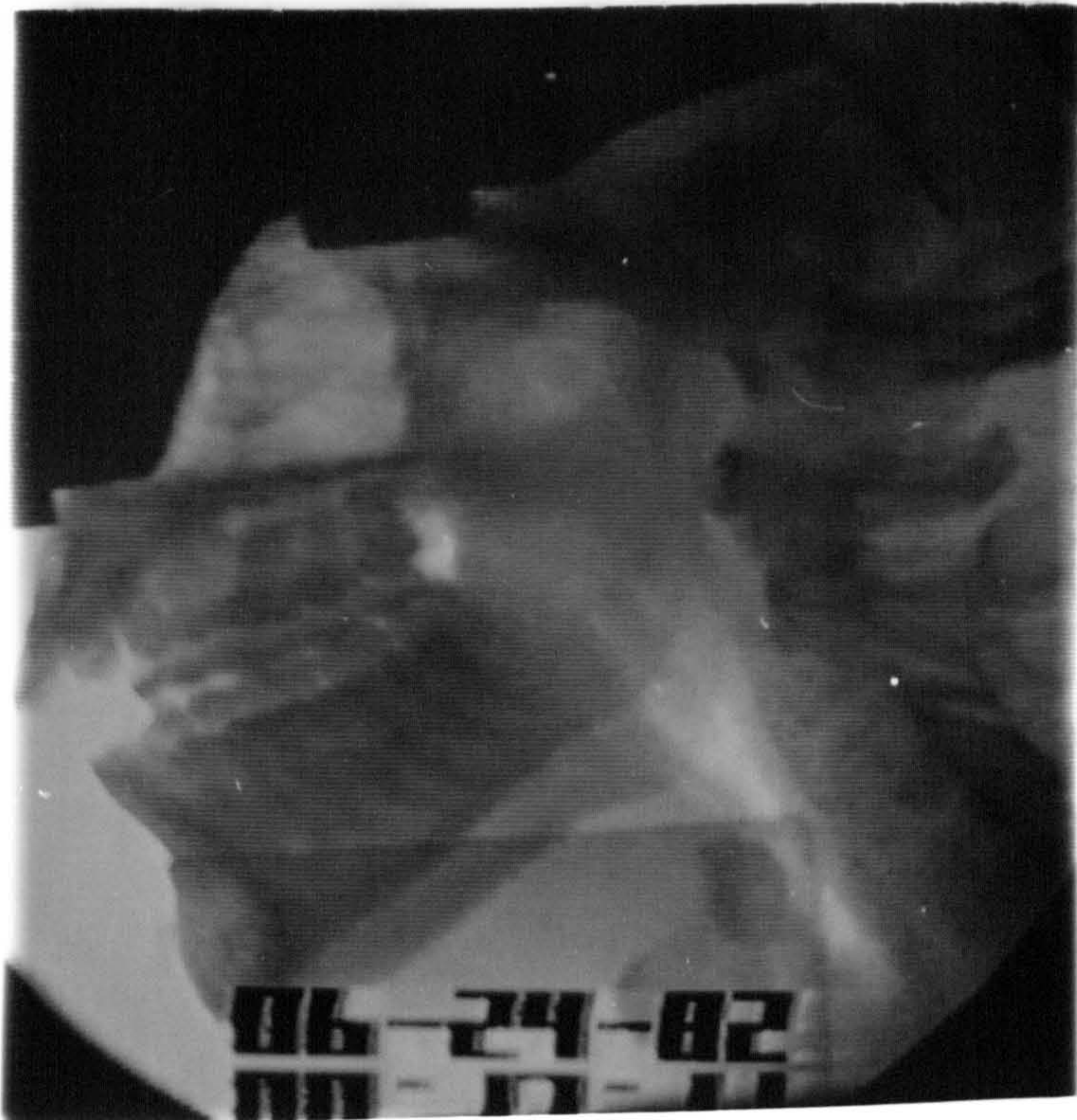
a. /t/ in /ta:b/ (FL)



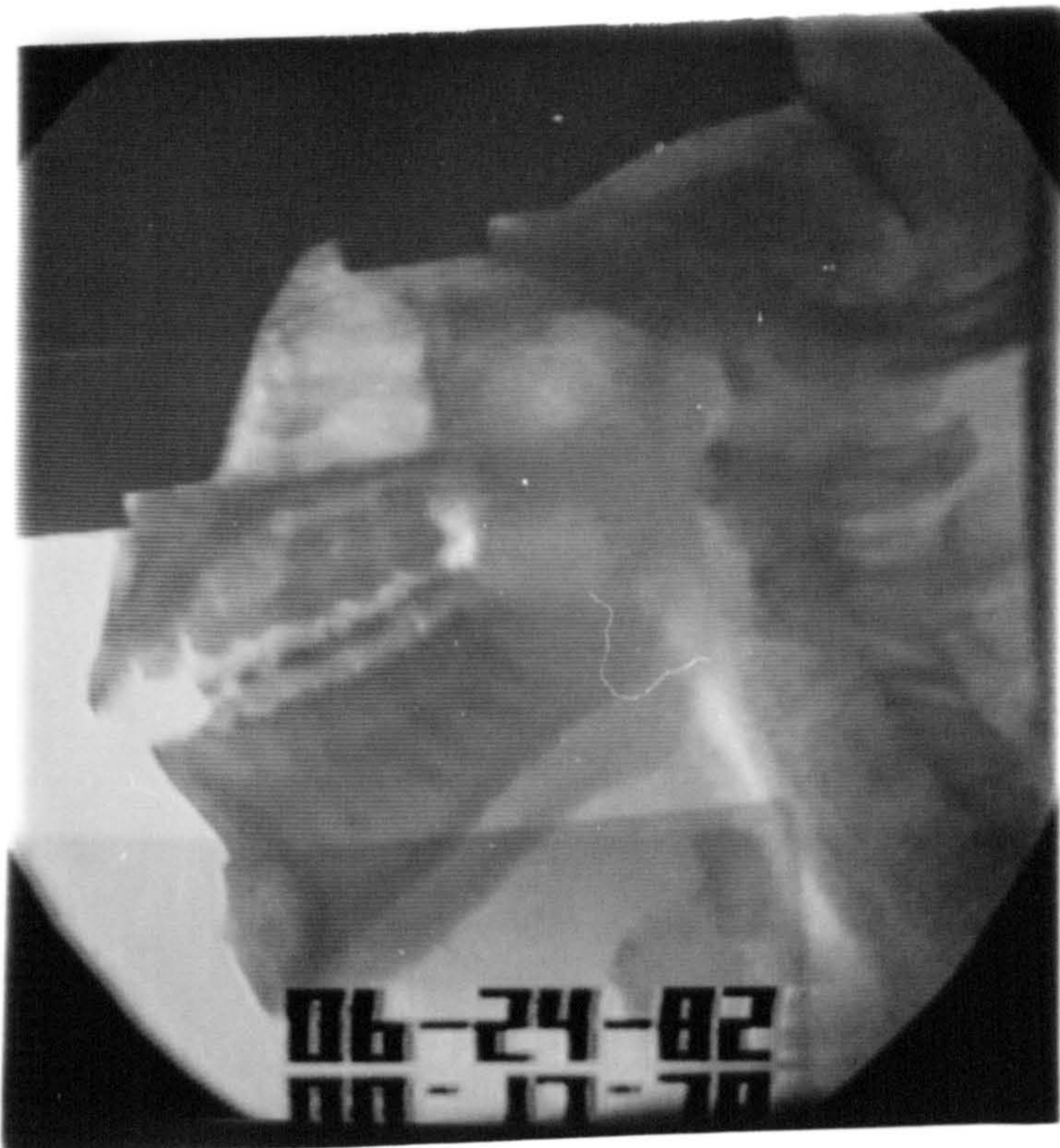
b. /T/ in /Ta:b/ (FL)

/a:/ occurs with /t/, which has a higher place of constriction, these two constrictions tend to occur at the same time, thus the presence of very small pharyngeal orifice. The dorsum of the tongue is lowered and retracted more in /Ta:b/ than it is for /ta:b/. A quite narrow constriction is observed for /a:/ in /Ta:b/ in contrast to /a:/ in /ta:b/, Figures 6.6.a and b respectively, and this constriction extends some distance down the pharynx. The laryngopharynx cavity is small. The maximum narrowing, however, lies about the level of C3, that is, with the epiglottis leaving a very small gap between itself and the back wall of the pharynx. The front and dorsum of the tongue are flattened with the dorsum retracted towards the back wall of the pharynx to form a second constriction.

/T/ in /Ti:n/, Figure 6.7.b in contrast to /t/ in /ti:n/, Figure 6.7.a, because the adjacent following vowel is front and close, the tongue is slightly retracted at the level of C2. The front of the tongue is raised. The cross-sectional shape below the level of C2 widens downwards. Unlike the xeroradiographic evidence of /i:/ in /ti:n/ and /Ti:n/, the examples in Figures 6.8.a and b of /i:/ in the same words show that there is a variation in the articulation of /i:/ adjacent to /t/ and /T/. Figure 6.8.b clearly shows the retraction of the dorsum of the tongue towards the back wall of the pharynx at the

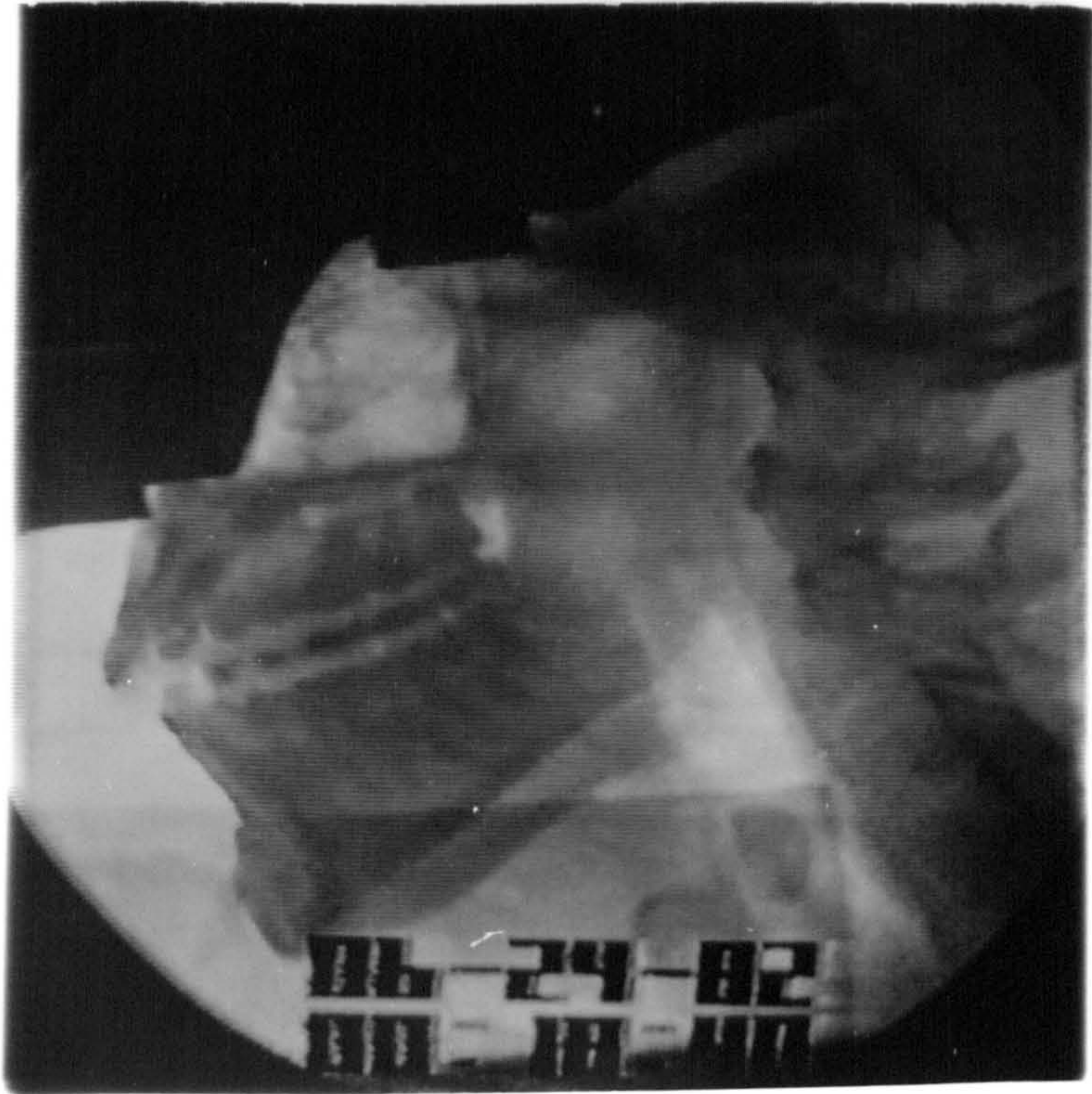


a. /a:/ in /ta:b/ (FL)

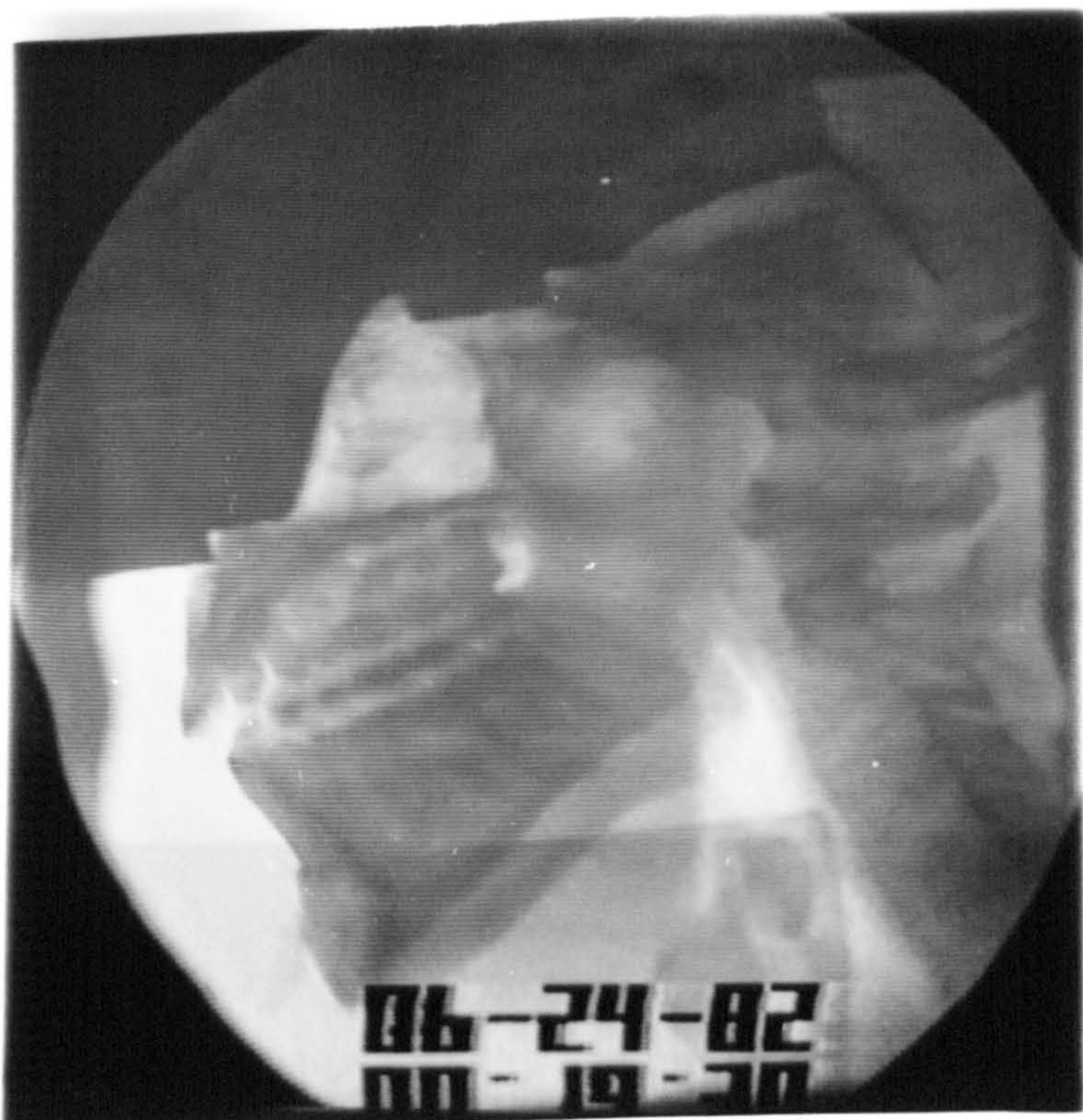


b. /a:/ in /Ta:b/ (FL)

Figure 6.6

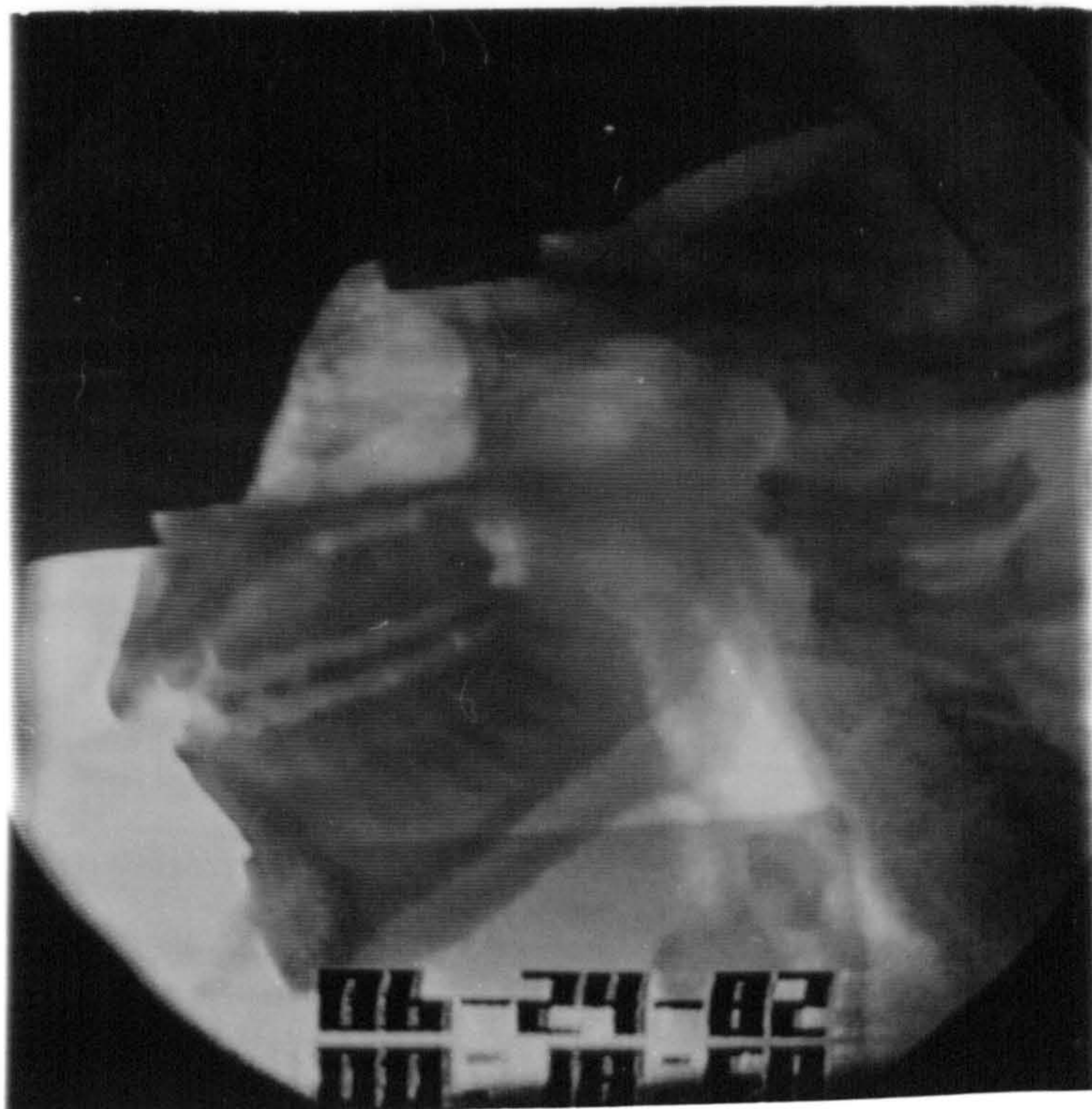


a. /t/ in /ti:n/ (FL)

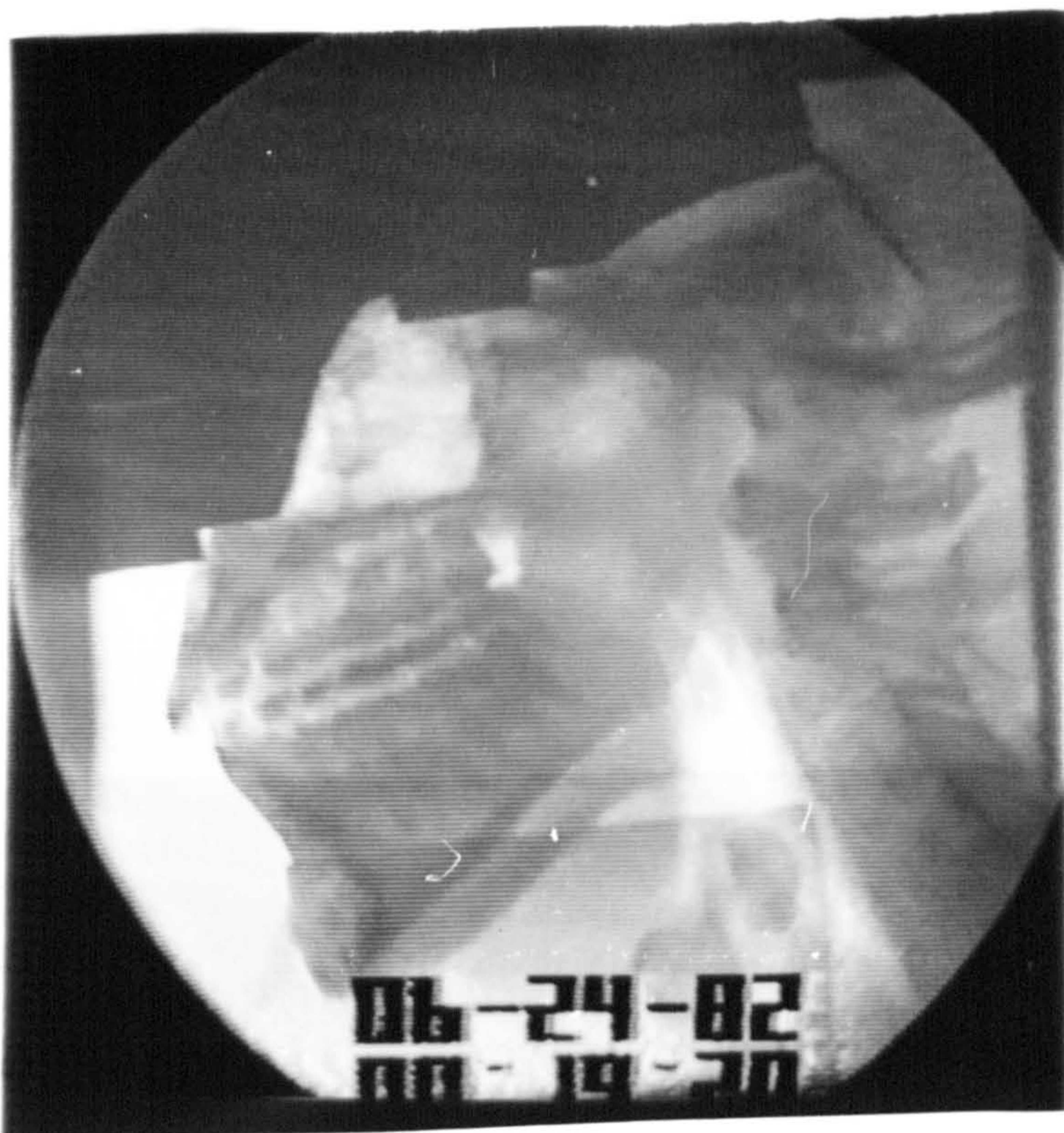


b. /T/ in /Ti:n/ (FL)

Figure 6.7



a. /i:/ in /ti:n/ (FL)



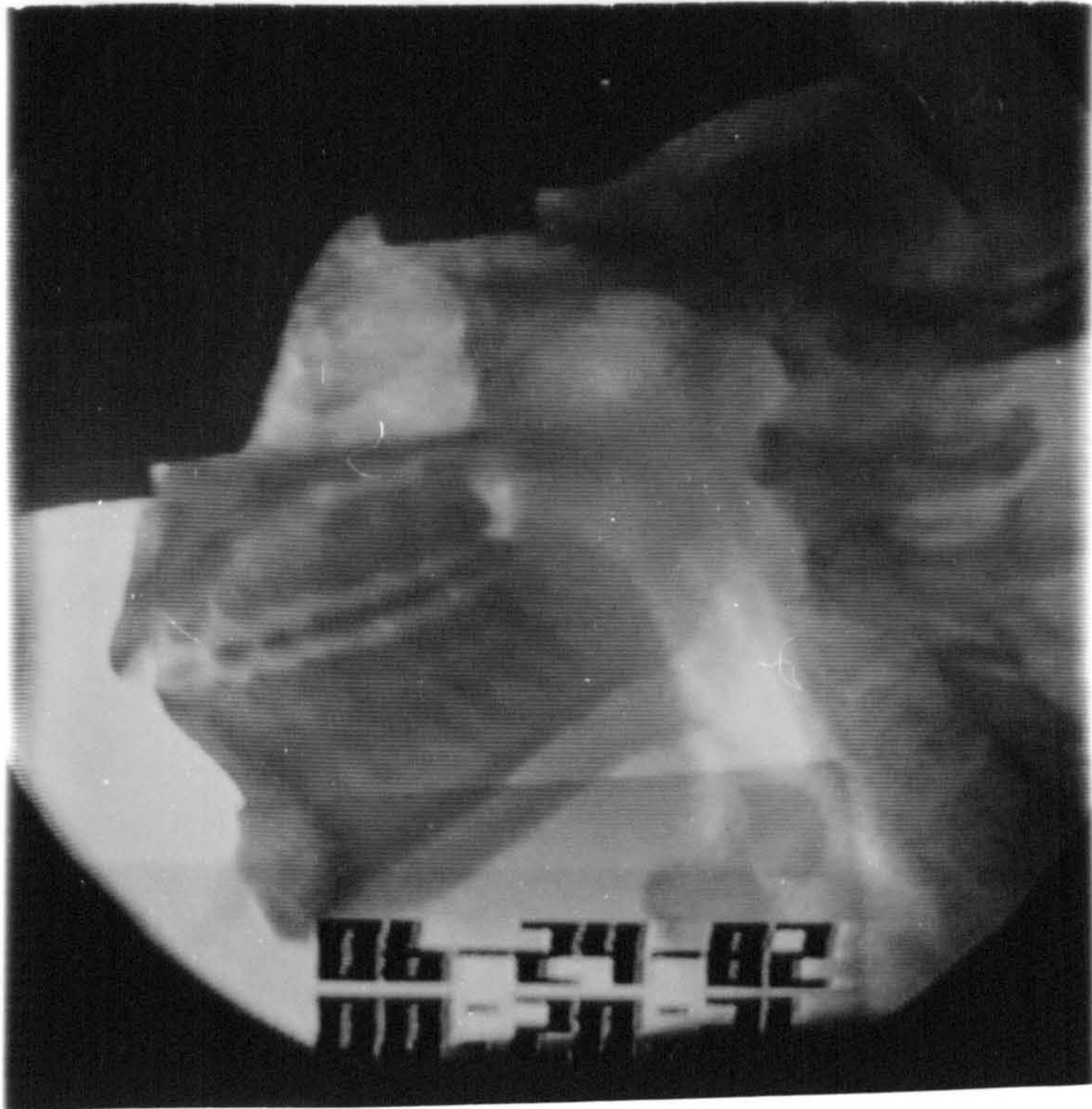
b. /i:/ in /Ti:n/ (FL)

Figure 6.8

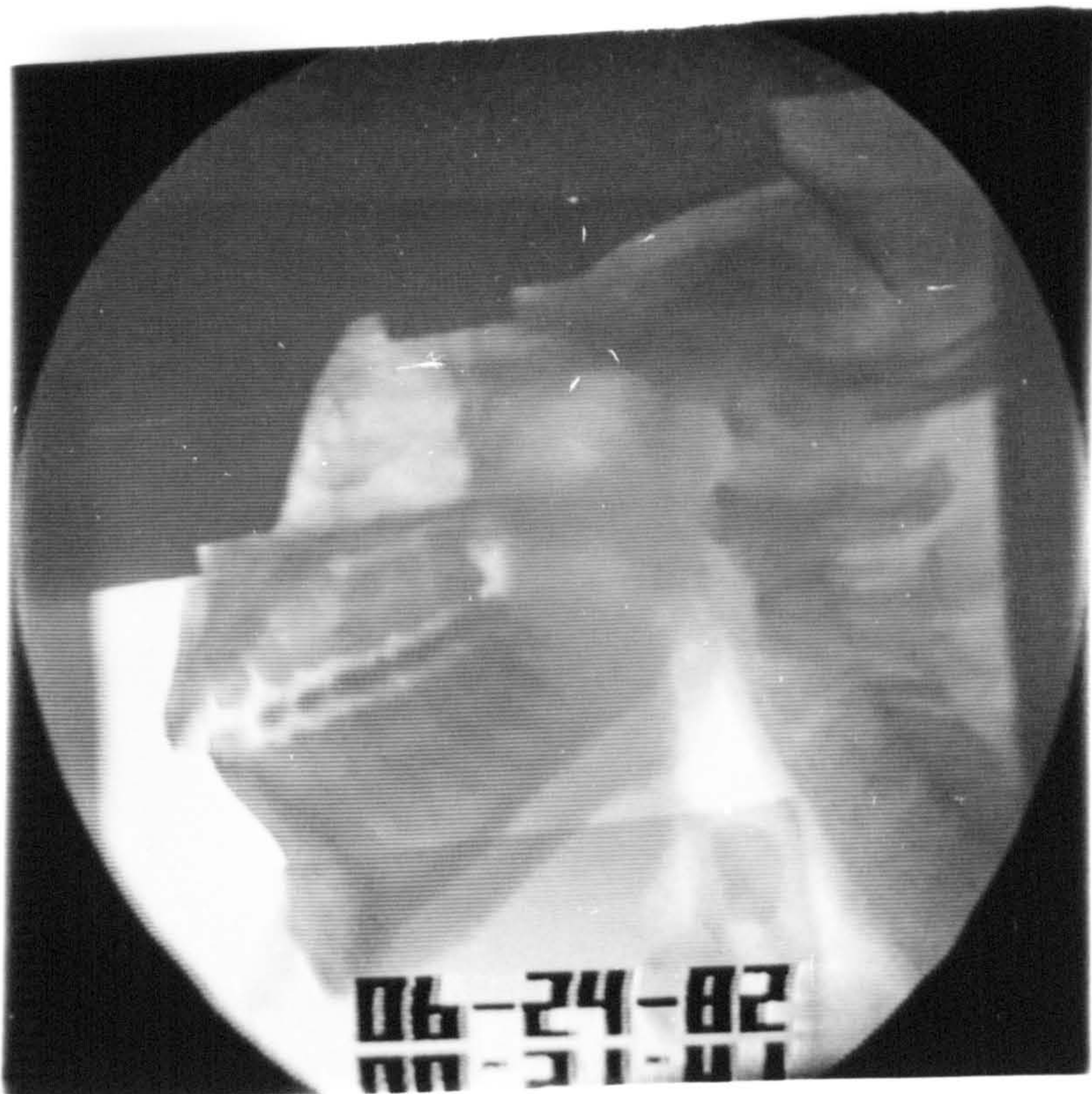
level of C2, which narrows the pharyngeal cavity, and also that the body of the tongue is raised towards the velum.

Figures 6.9.a and b of /t/ in /tu:b/ and /T/ in /Tu:b/. Both examples show the back of the tongue raised towards the soft palate. However, in /Tu:b/, the dorsum of the tongue is more retracted and further raised even than /S/ in /So:m/ Figure 6.14.b. This is to be expected, as /T/ is adjacent to the close back vowel /u:/, and because the vowel is long, the retraction and raising is enhanced. The narrowest constriction is at the level between C1 and C2. The area below the constriction widens and the laryngopharyngeal cavity is large. The gap and the area between the root of the tongue and the epiglottis is larger than for all the other sounds. As for the adjacent vowel, /u:/ in /Tu:b/, Figure 6.10.b in contrast to /u:/ in /tu:b/, a very similar configuration of the articulators is seen as for /T/ in /Tu:b/. The dorsum of the tongue is raised higher for the vowel than for the consonant, leaving a small gap between the soft palate and the dorsum of the tongue.

Figures 6.11.a and b of /dull/ and Dull/ respectively. The constriction extends to the same extent along the pharynx. However, the constriction for /Dull/ takes place at the level of C2 and C3 in relation to /dull/, where the tongue dorsum is raised towards the soft palate. There is

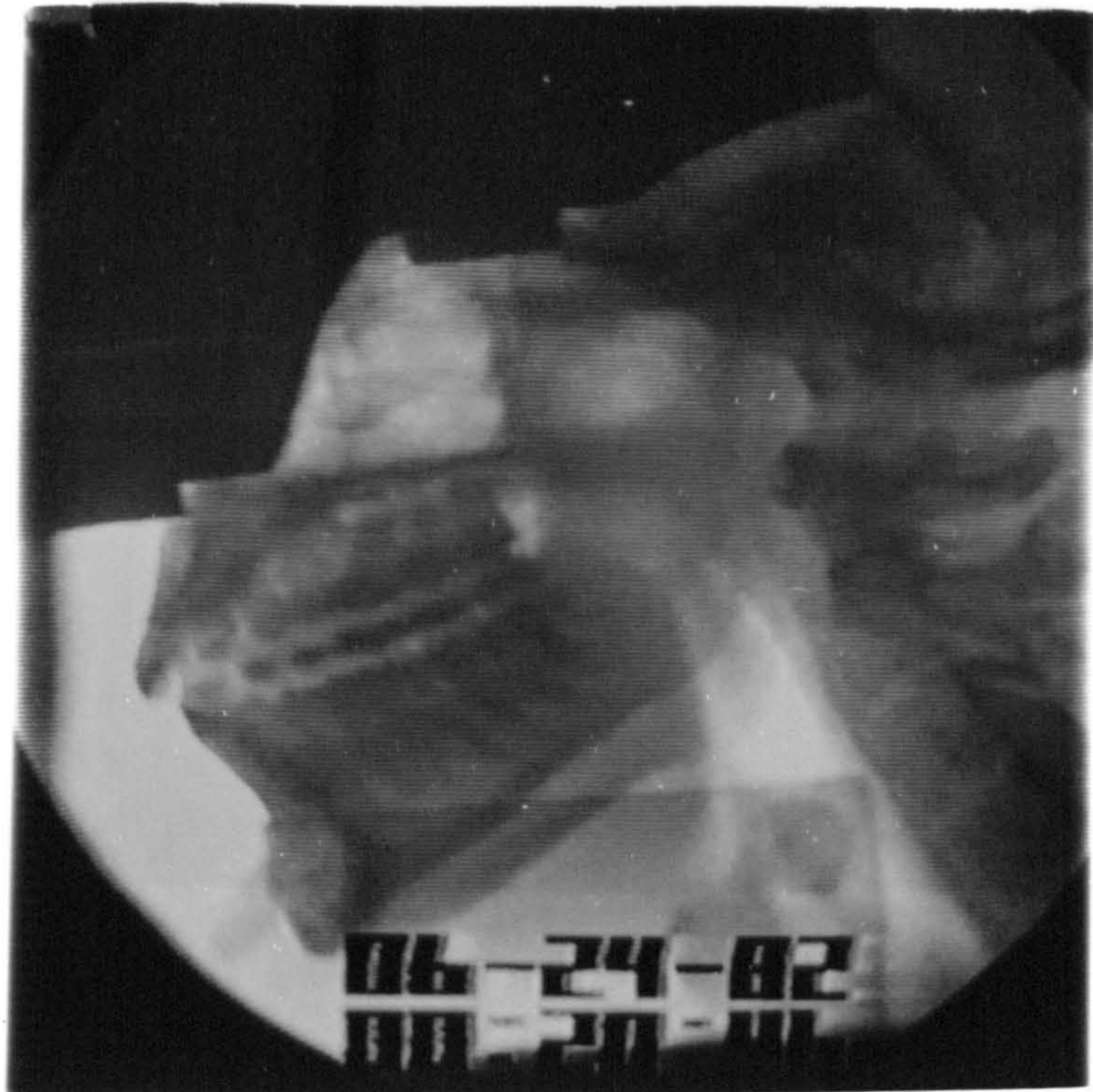


a. /t/ in /tu:b/ (FL)



b. /T/ in /Tu:b/ (FL)

Figure 6.9

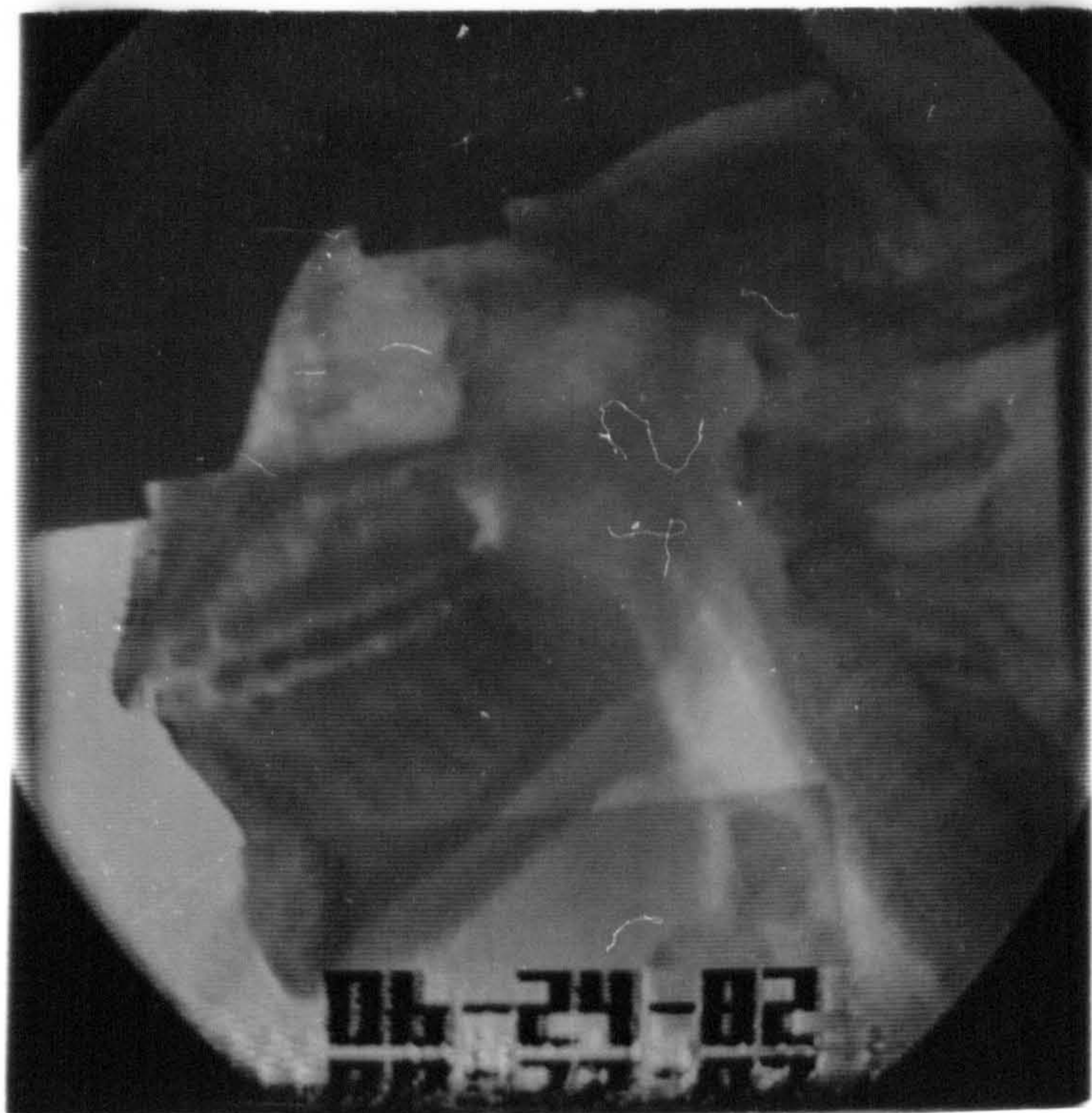


a. /u:/ in /tu:b/ (FL)

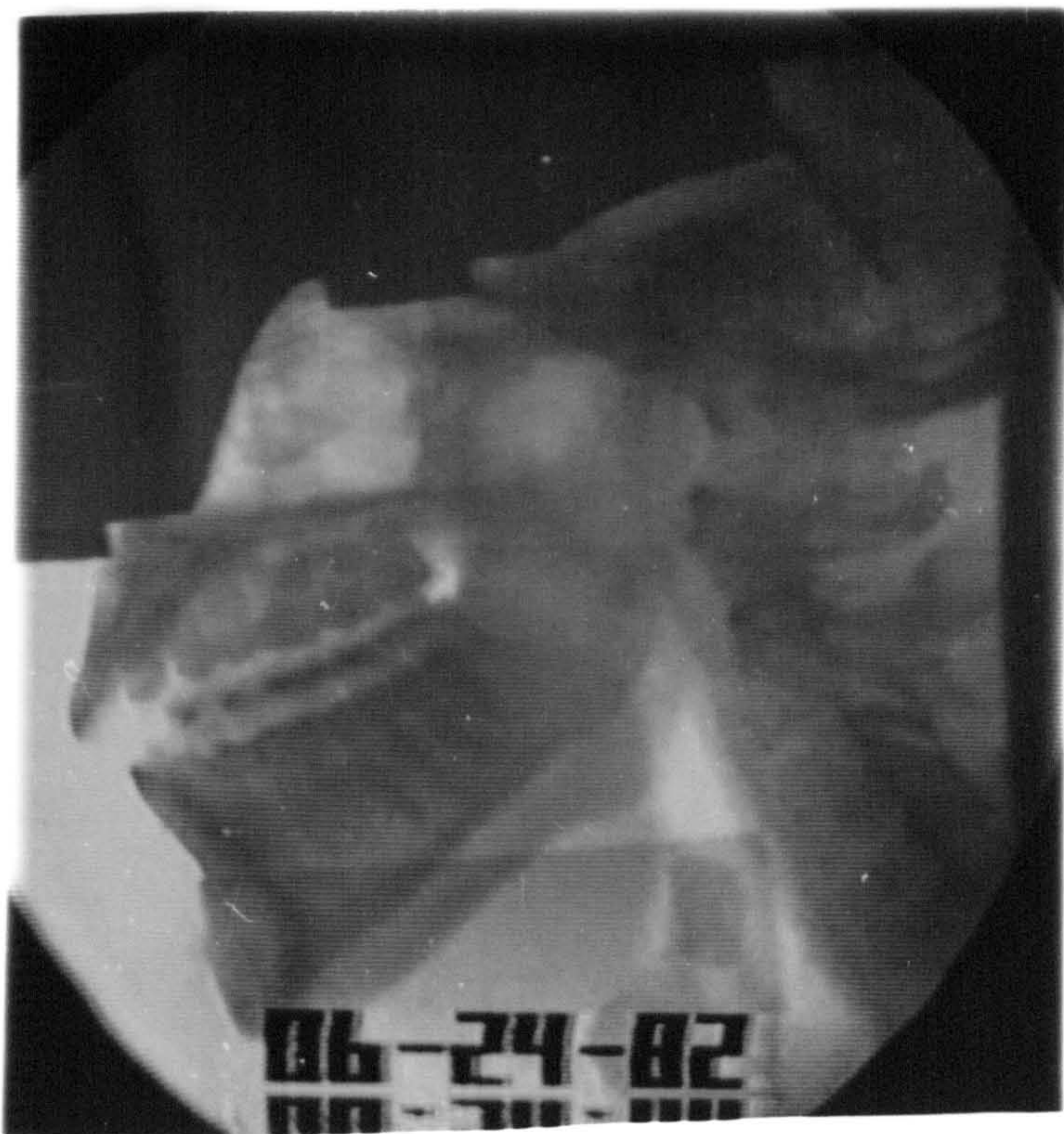


b. /u:/ in /Tu:b/ (FL)

Figure 6.10



a. /d/ in /dull/ (FL)



b. /D/ in /Dull/ (FL)

Figure 6.11

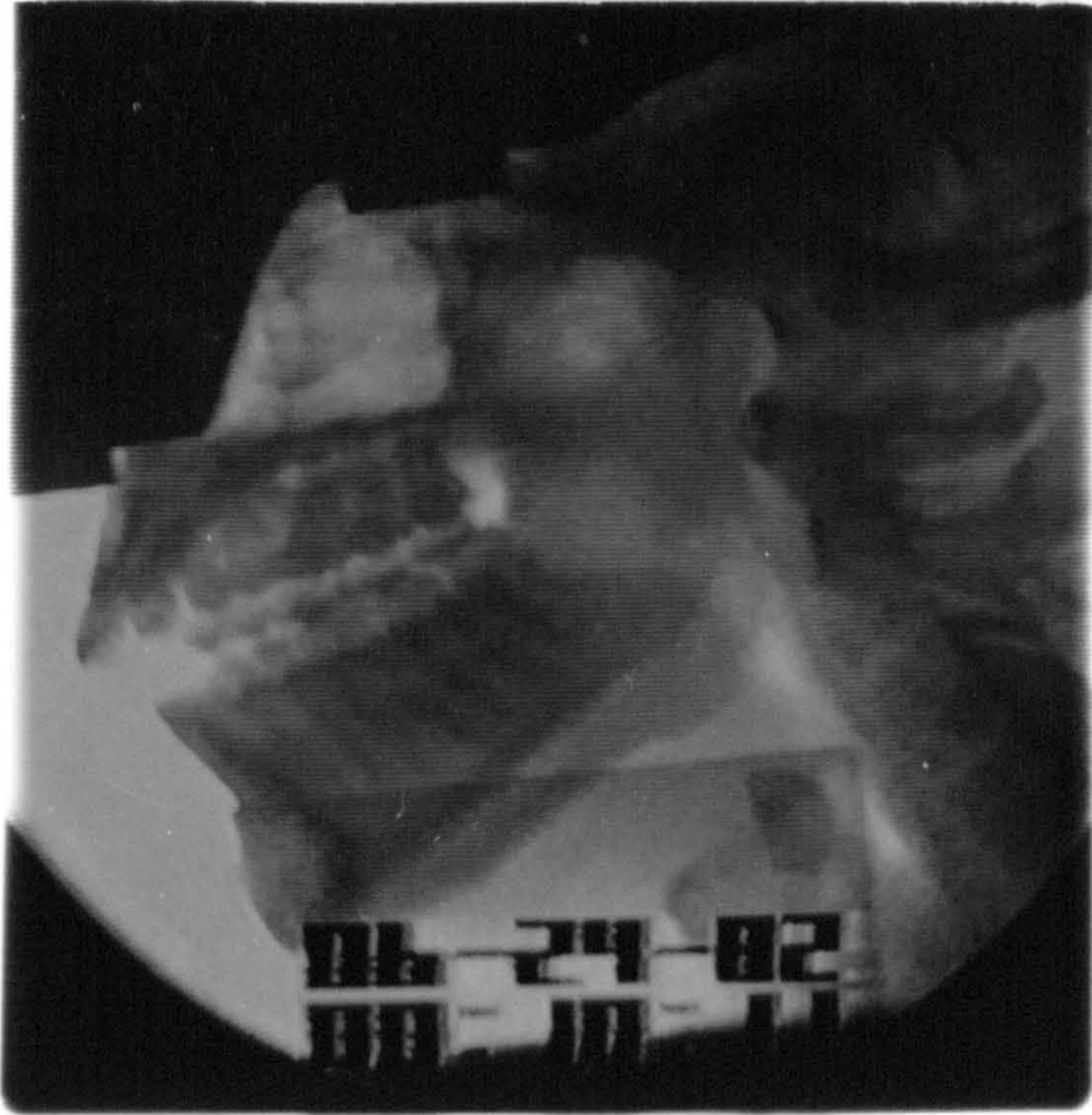
for /Dull/, a large laryngopharyngeal orifice. One may draw a comparison, though not complete, between the pair /dull/, /Dull/ and /tu:b/, /Tu:b/, where the constriction for the consonants /D/ and /T/ are very similar though the following vowels are different in quantity.

In Figure 6.12.a of /a/ in /ʎaDD/, the constriction is great in the pharynx at the level of the epiglottis, very similar to examples of the pharyngeal consonants /ʒ/ and /ʁ/.

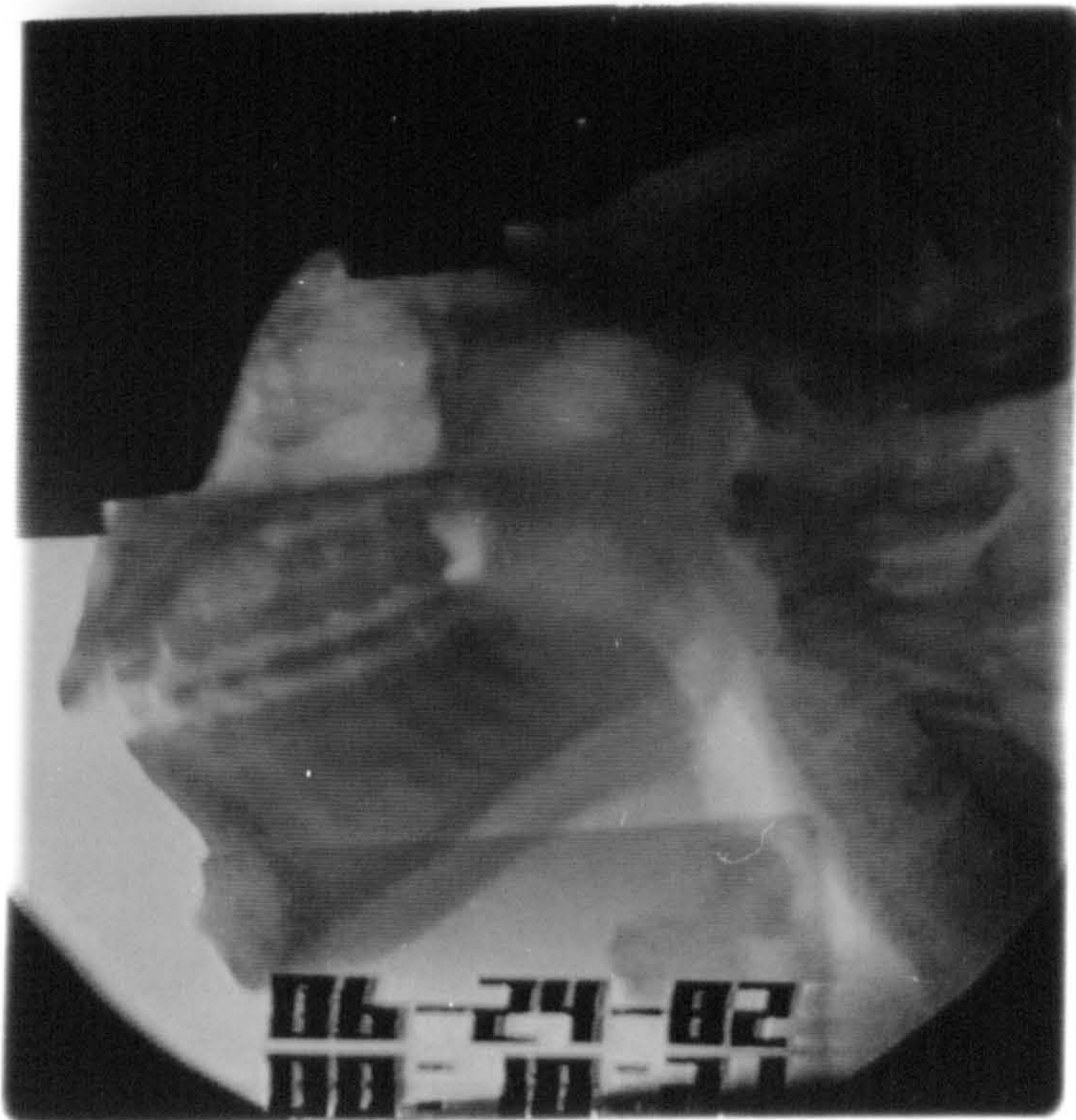
Figure 6.12.b of /DD/ in /ʎaDD/, this particular frame may be of the articulators either just moving towards or away from the target articulation as the constriction is not as expected for a pharyngealized sound. It is very difficult to determine the location of the tip or blade of the tongue. The dorsum of the tongue is more lowered for /a/ than for /DD/.

In Figures 6.13.a and b of /T/ and /e:/ in /ʎe:T/, there is a very slight constriction in the pharynx for /T/; the difference is very small, about 1 mm.

In Figures 6.14.a and b of the consonants /s/ and /S/ in /so:m/ and /So:m/ respectively, the difference between the two examples is not great. The pictures of /so:m/ and /So:m/ are similar except that in /So:m/ the dorsum and root of the tongue take a rather round shape

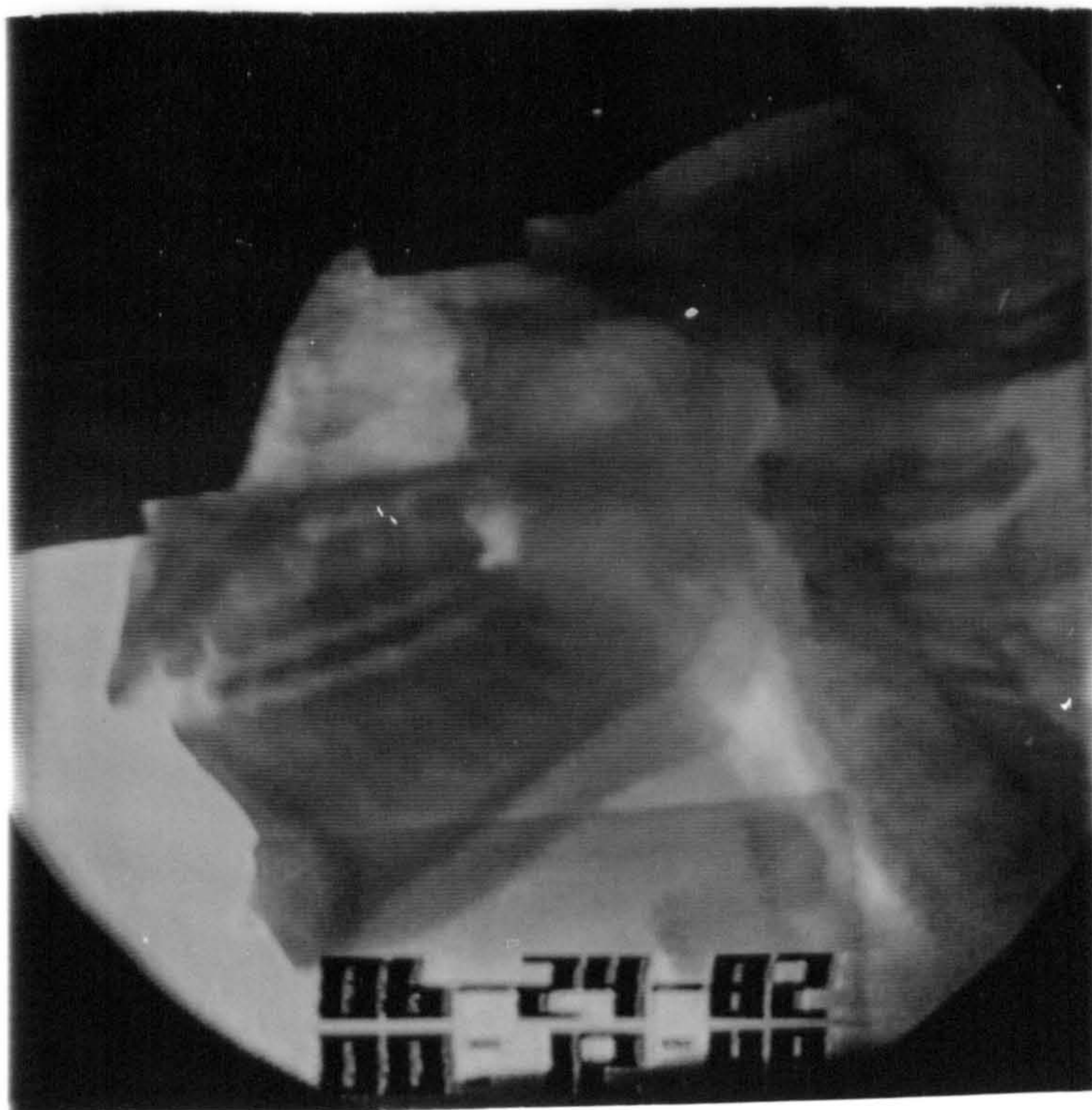


a. /a/ in /MaDD/ (FL)

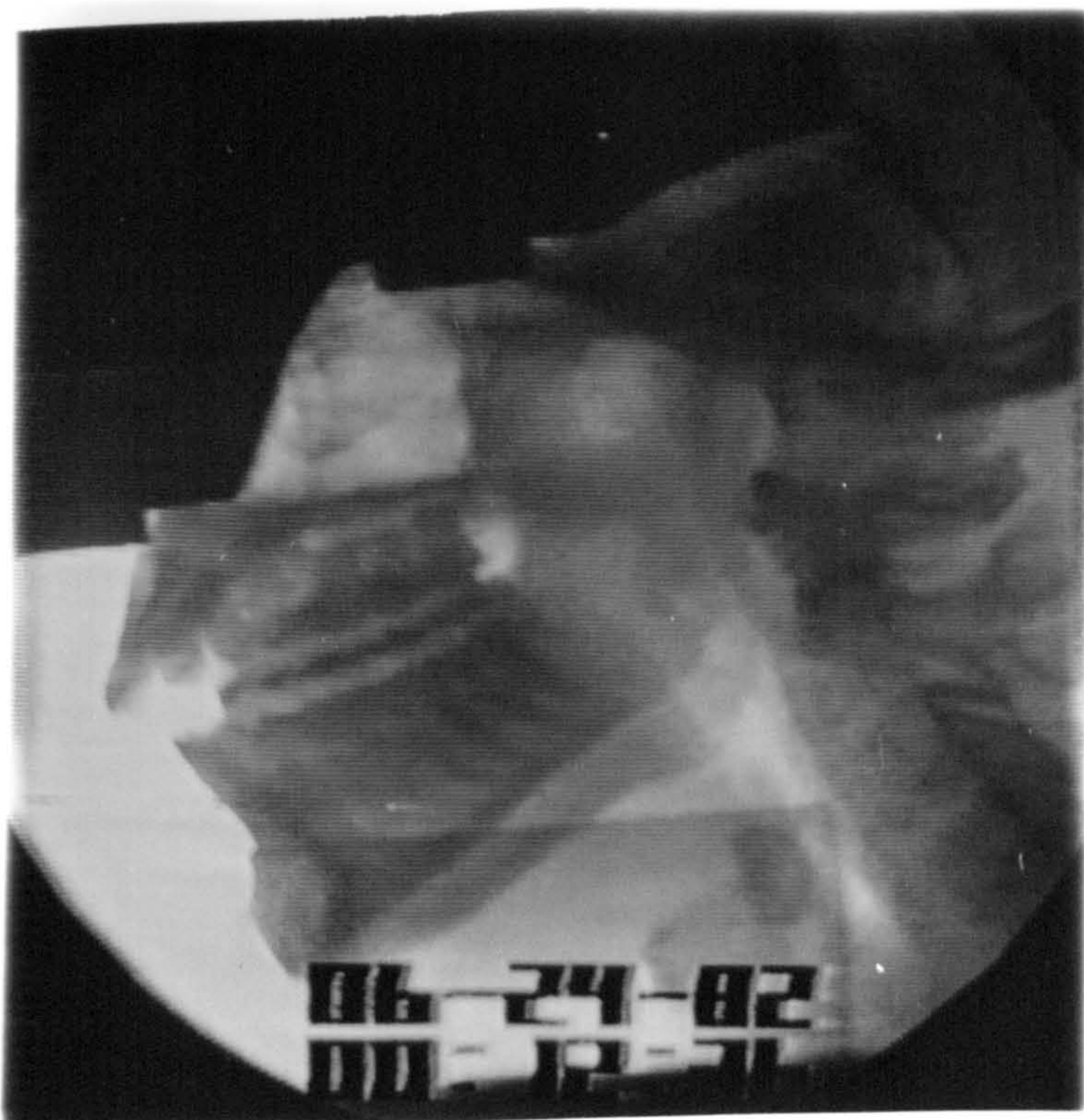


b. /DD/ in /MaDD/ (FL)

Figure 6.12

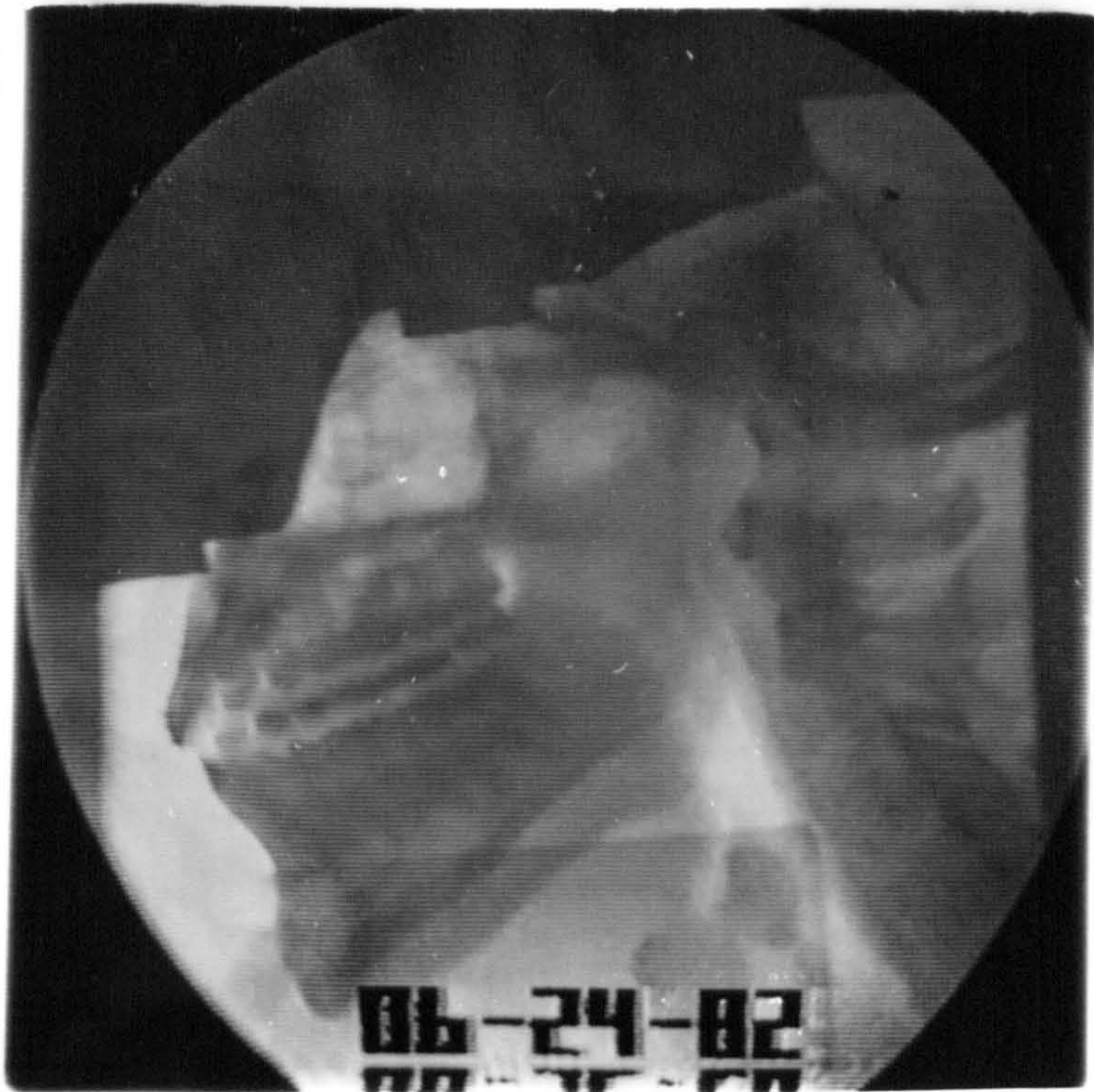


a. /T/ in /Me:T/ (FL)

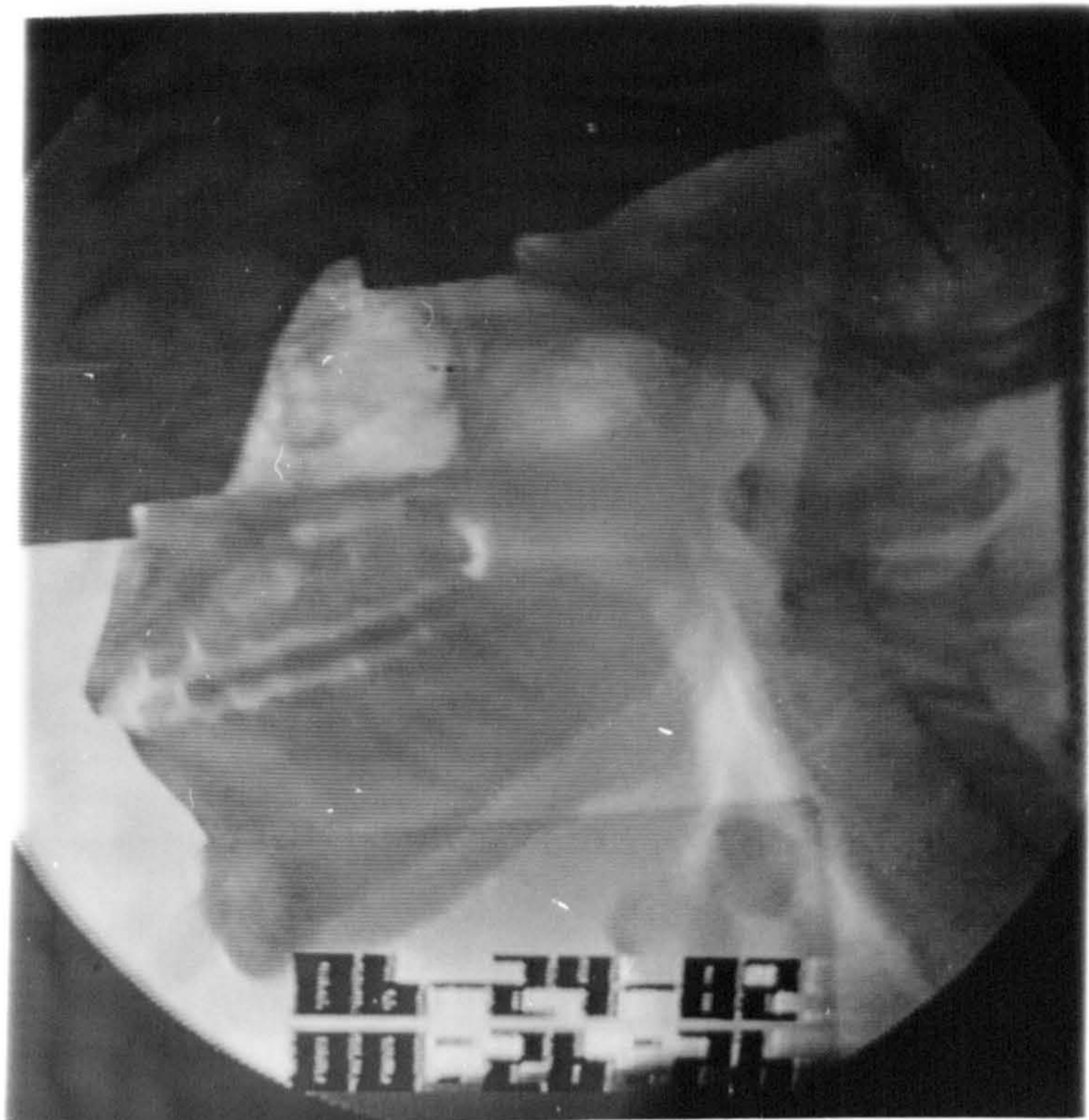


b. /e:/ in /Me:T/ (FL)

Figure 6.13



a. /s/ in /so:m/ (FL)

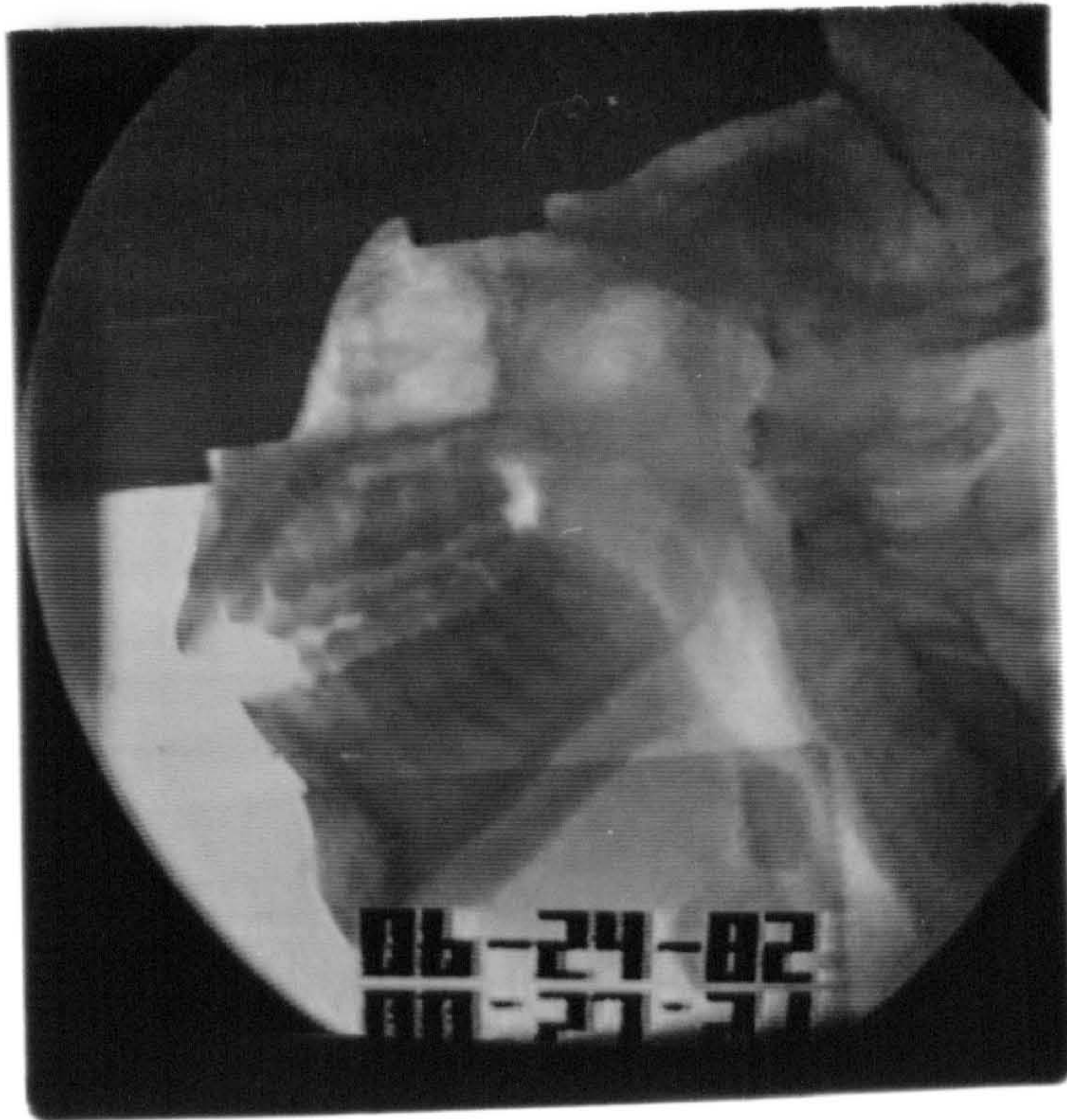


b. /S/ in /So:m/ (FL)

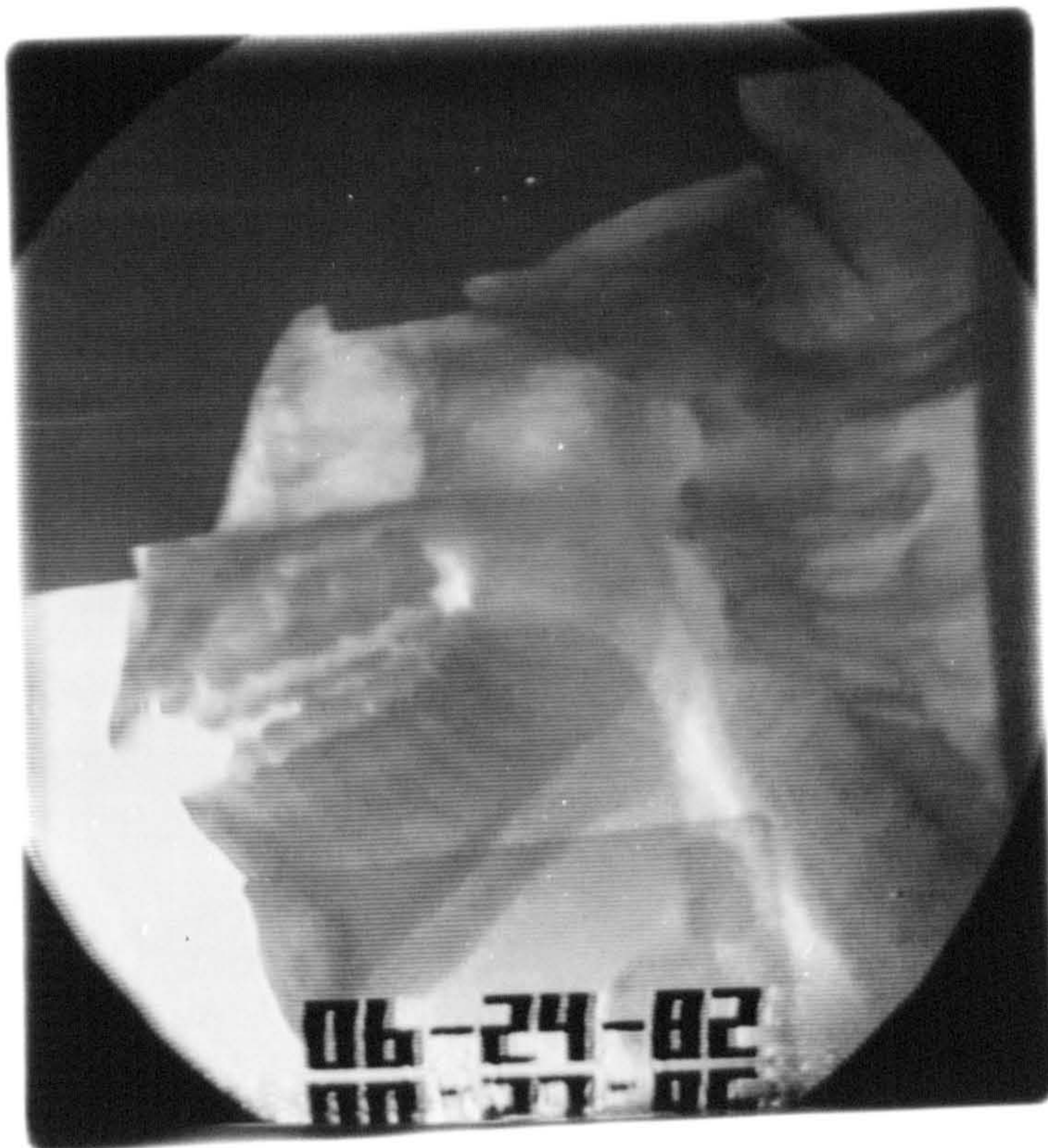
Figure 6.14

which results in some constriction at the level of C2 in the pharynx, whereas, in /so:m/, the shape is flattish with almost the same degree of constriction along the pharyngeal area. The constriction in the pharynx at a level extending over C1 and C2 is slightly more for /S/ than for /s/. The constriction in the pharynx for the vowel /o:/ in /So:m/ has a similar shape to that of /S/, the tongue, however, is slightly lowered. The raised position of the body of the tongue in /S/ is a consequence of the raising of the blade against the alveolar ridge. One observes also that the epiglottis is retracted away from the root of the tongue which is not the case for the vowel /o:/.

Figures 6.15.a and b, of /ll/ and /LL/ in /walla/ and /waLLa/ respectively, show a difference in the size of the pharynx. There is a constriction in the pharynx for /LL/, though not as great as for the examples of /S/ and /T/. In /waLLa/, the tongue is lowered and retracted, probably as a consequence of the adjacent open vowels. The narrowest constriction is between the epiglottis and the root of the tongue. The front of the tongue is raised towards the alveolar ridge. If the pharyngealized/non-pharyngealized consonants in /walla/ and /waLLa/ are to be compared with those of /ta:b/ and /Ta:b/, Figures 6.5.a and b, unexpected findings appear.



a. /ll/ in /walla/ (FL)



b. /LL/ in /waLLa/ (FL)

Figure 6.15

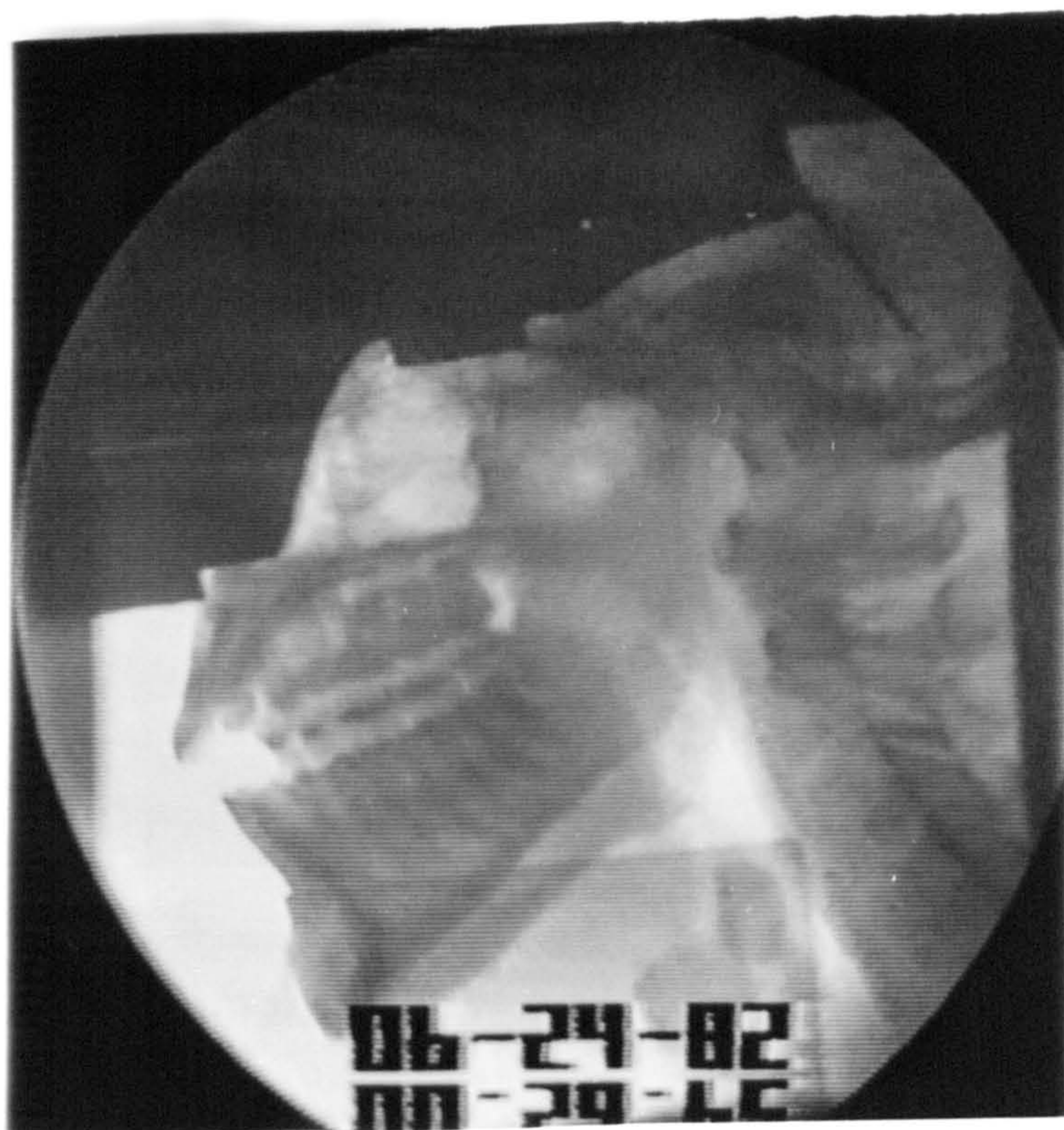
In /ta:b/, there is more constriction at the level of the epiglottis and a little wider in the area against the soft palate. This is a result of the front of the tongue stretching to make contact between the tip and blade and the upper teeth at the same time keeping the retracted position in the pharynx, whereas, for /walla/, the tongue is laterally expanded and the tip is against the alveolar ridge; that is, in a more retracted position than in /ta:b/. However, in /Ta:b/ and /waLLa/, the constriction is greater for the former than for the latter. One may venture to speculate that the difference between the two articulations may be due to a) the length of the vowel which requires more tension and probably more constriction in the area and b) that the secondary pharyngealized /L/ does not have the same pharyngeal articulatory requisite as that for the primary pharyngealized /T/.

It was found that /ʒ/ in /ʒa:ri/ has a constriction in the pharynx probably as an influence of /a:/. The front of the tongue is raised against the palate in both examples, and the dorsum is raised more for /ʒ/ in /ʒa:ri/ than it is for the second example, at the same time being held away from the back wall of the pharynx.

In Figures 6.16.a and b of /ɪ/ in /ʒa:ri/ and /ʒa:ri/ respectively, there is no significant difference



a. /i/ in /ʒa:ri/ (FL)

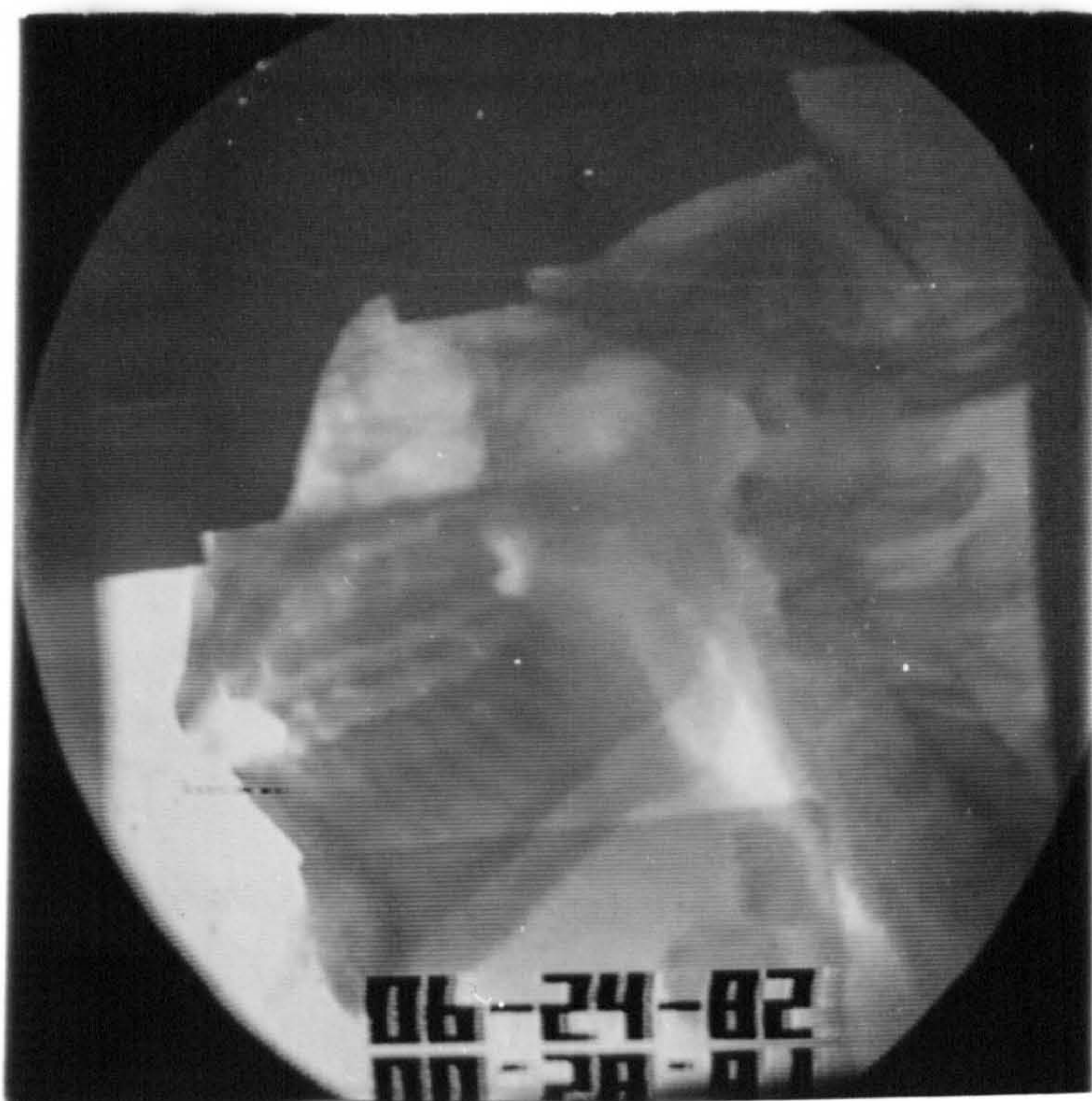


b. /i/ in /ʒa:ri/ (FL)

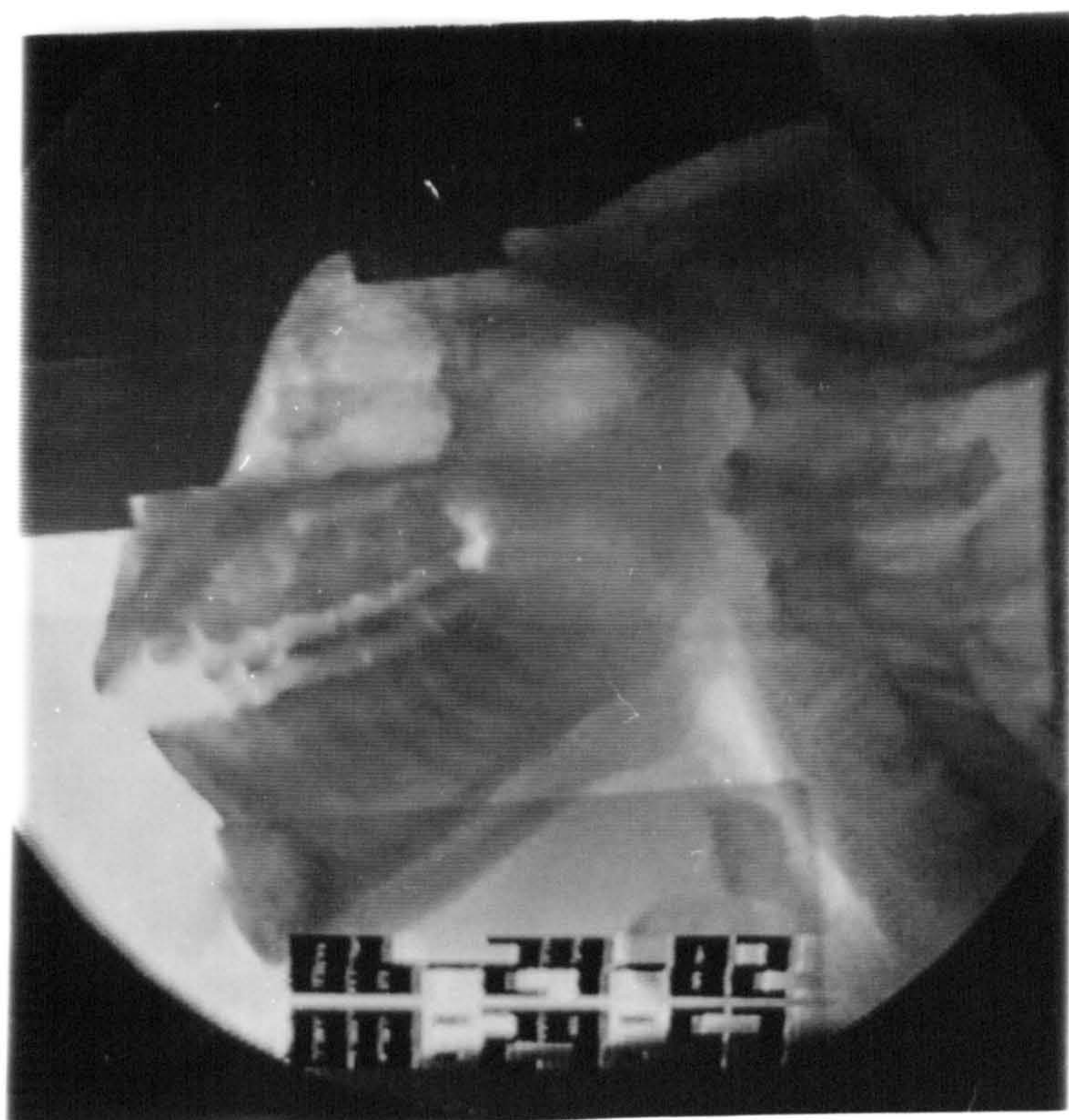
Figure 6.16

between the two examples. This shows that the final /i/ is not retracted under the influence of the adjacent sounds assuming that /r/ is retracted.

As for /a:/ in /ʒa:ri/, Figure 6.17.b in relation to /a:/ in /ʒa:ri/, Figure 6.17.a, there is a constriction in the pharynx with the narrowest point taking place at the level of the epiglottis. The soft palate is in firm contact with the back wall of the pharynx.



a. /a:/ in /ʒa:ri/ (FL)



b. /a:/ in /ʒa:ri/ (FL)

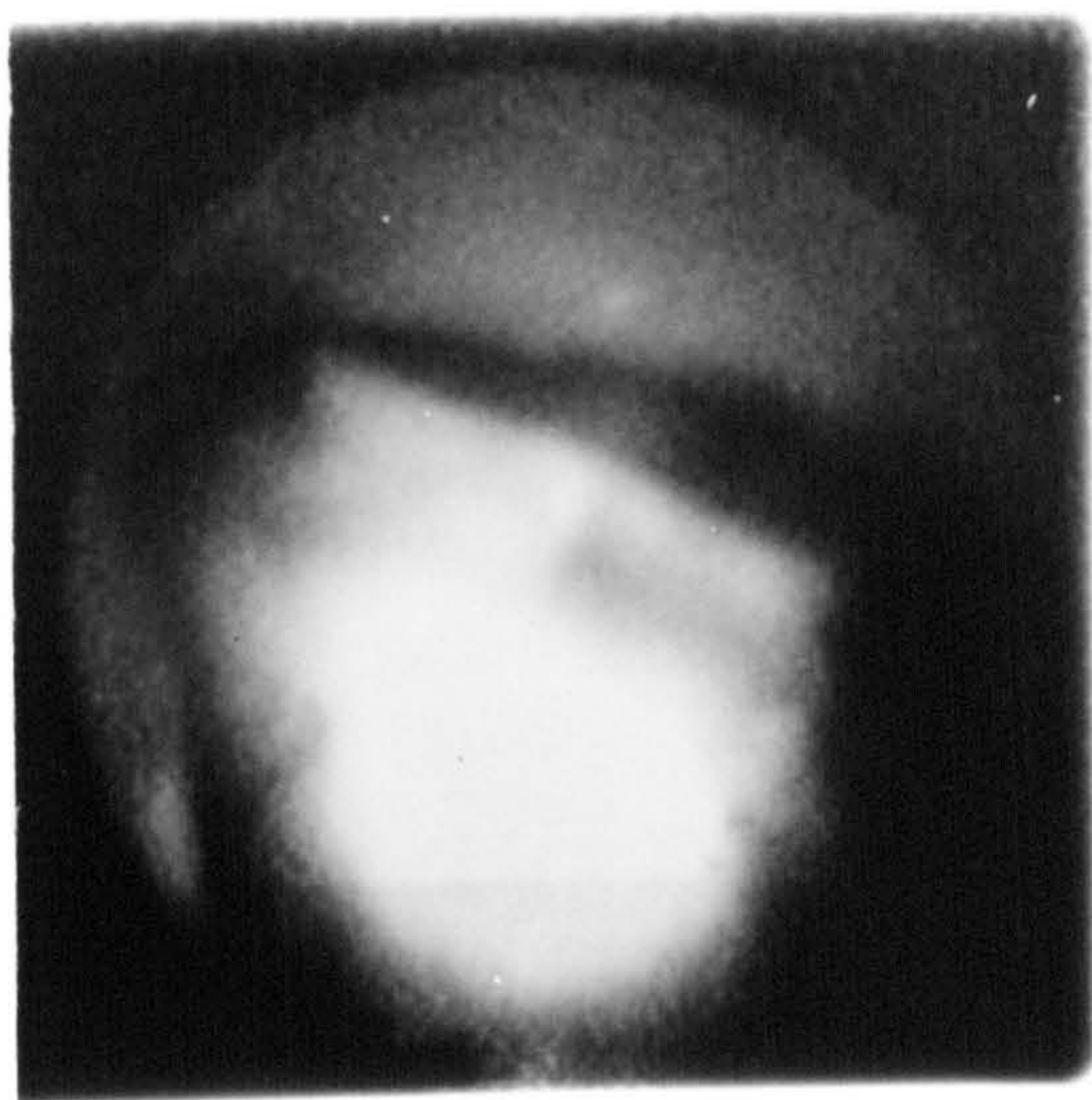
Figure 6.17

Endoscopic analysis

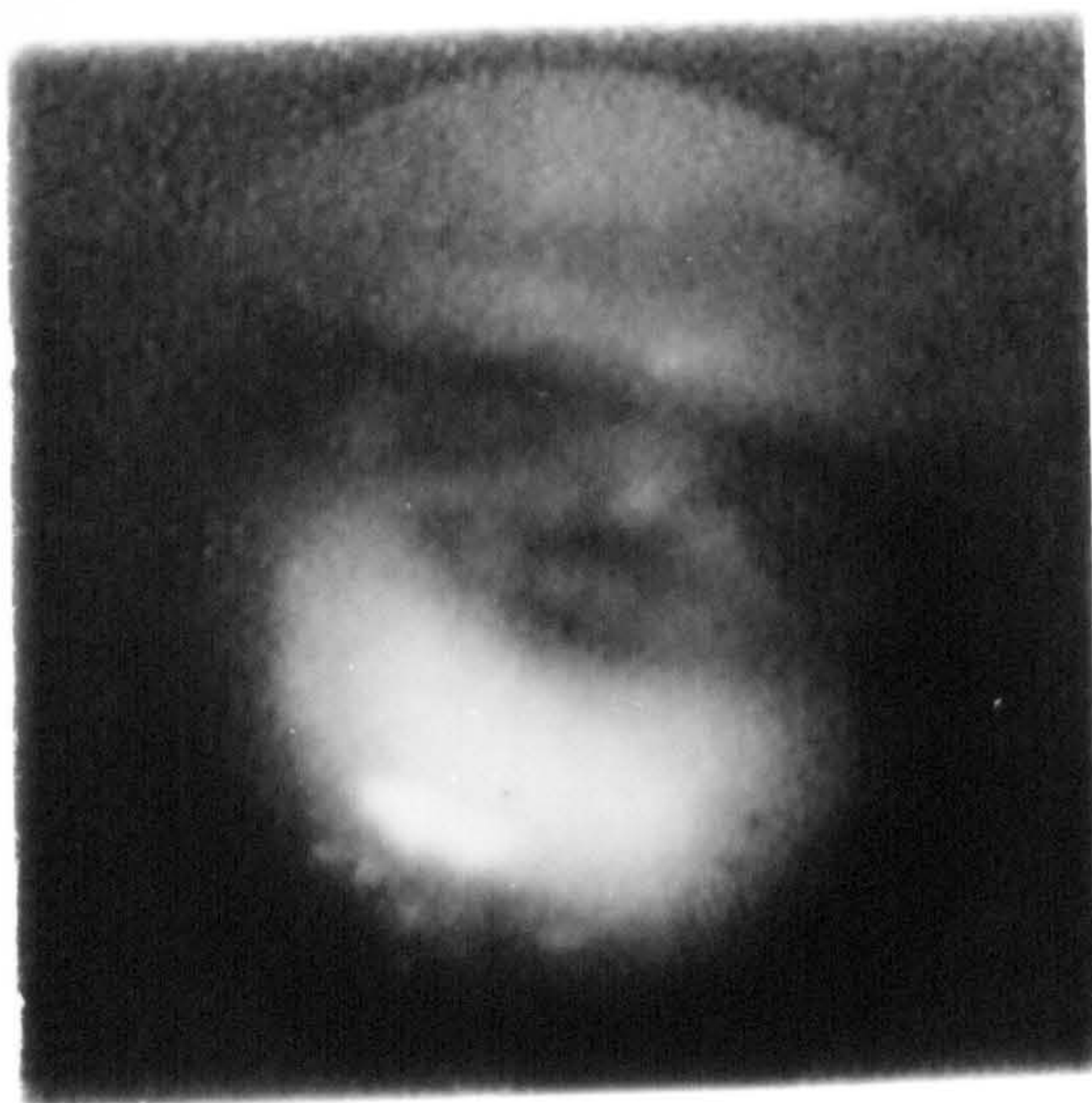
In general, the articulation of the pharyngealized consonants is manifested in the retraction of the epiglottis towards the back wall of the pharynx. The degree of retraction varies from one subject to another. Subject (SA) articulation of the pharyngealized consonants exhibited the maximum constriction observed in relation to his non-pharyngealized counterparts. Figure 6.18.a and c. show the non-pharyngealized consonants /t/ and /s/ in /ta:b/ and /se:f/ respectively. The position or shape of the epiglottis has not changed from that of the 'at rest' position. The larynx can be clearly seen because the epiglottis does not obstruct the view as it does for the examples of /T/ and /S/ in /Ta:b/ and, /Se:f/ Figure 6.18.b and d respectively. In b. and d., the epiglottis is considerably retracted towards the back wall of the pharynx and its upper edge is uncurled, a typical gesture observed during the articulation of the pharyngealized consonants. The root of the tongue retracts until it touches the uncurled edge of the epiglottis, though, it does not appear clearly in these photographs. In b, the constriction of the right lateral wall can be seen. This maximal constriction for the pharyngealized consonants, which is exhibited in the endoscopic film of words spoken by the Iraqi subject (SA) may be a typical feature of Iraqi speech, as it is also found in MacCurtain's



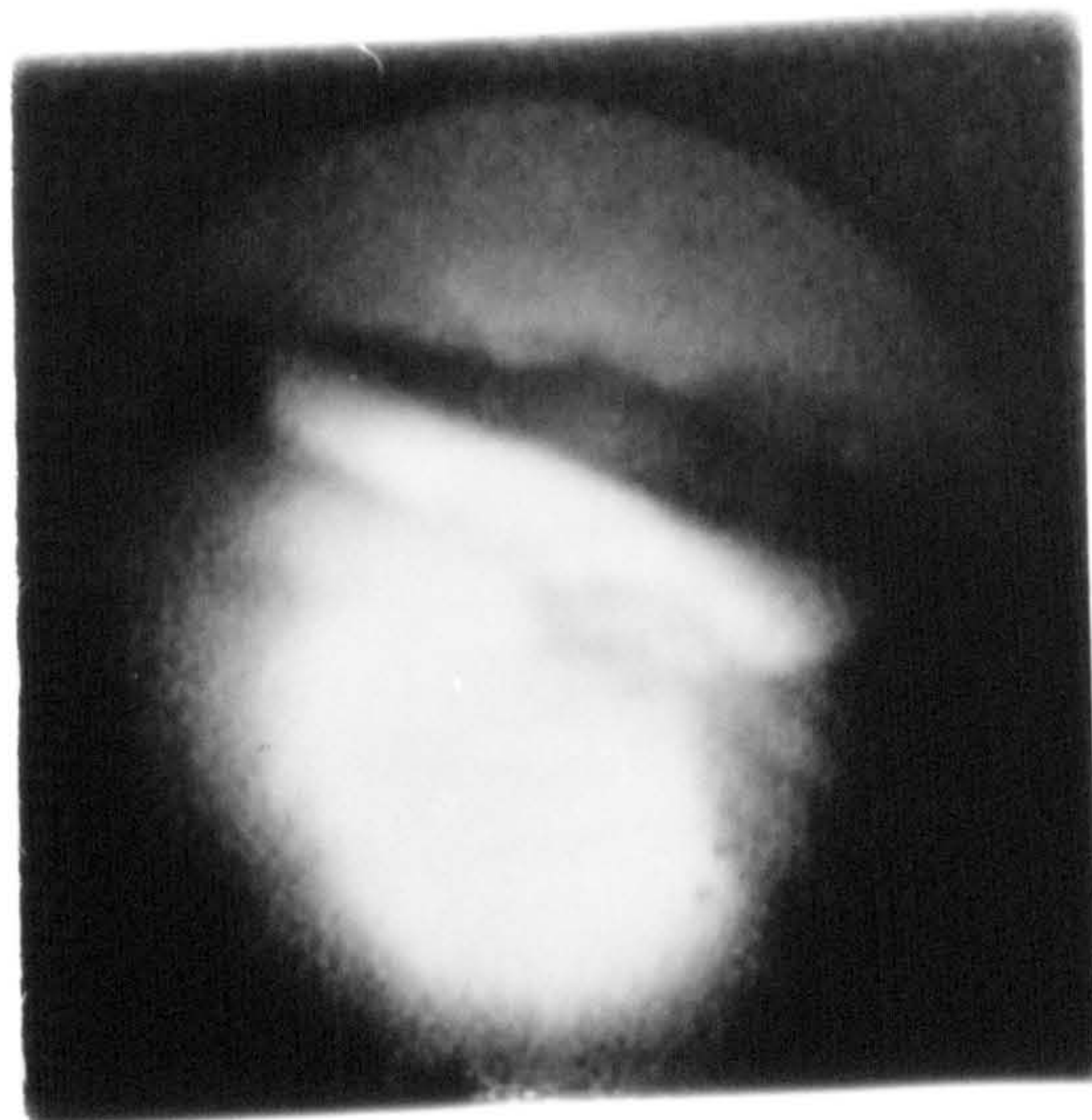
a. /t/ in /ta:b/ (SA)



b. /T/ in /Ta:b/ (SA)

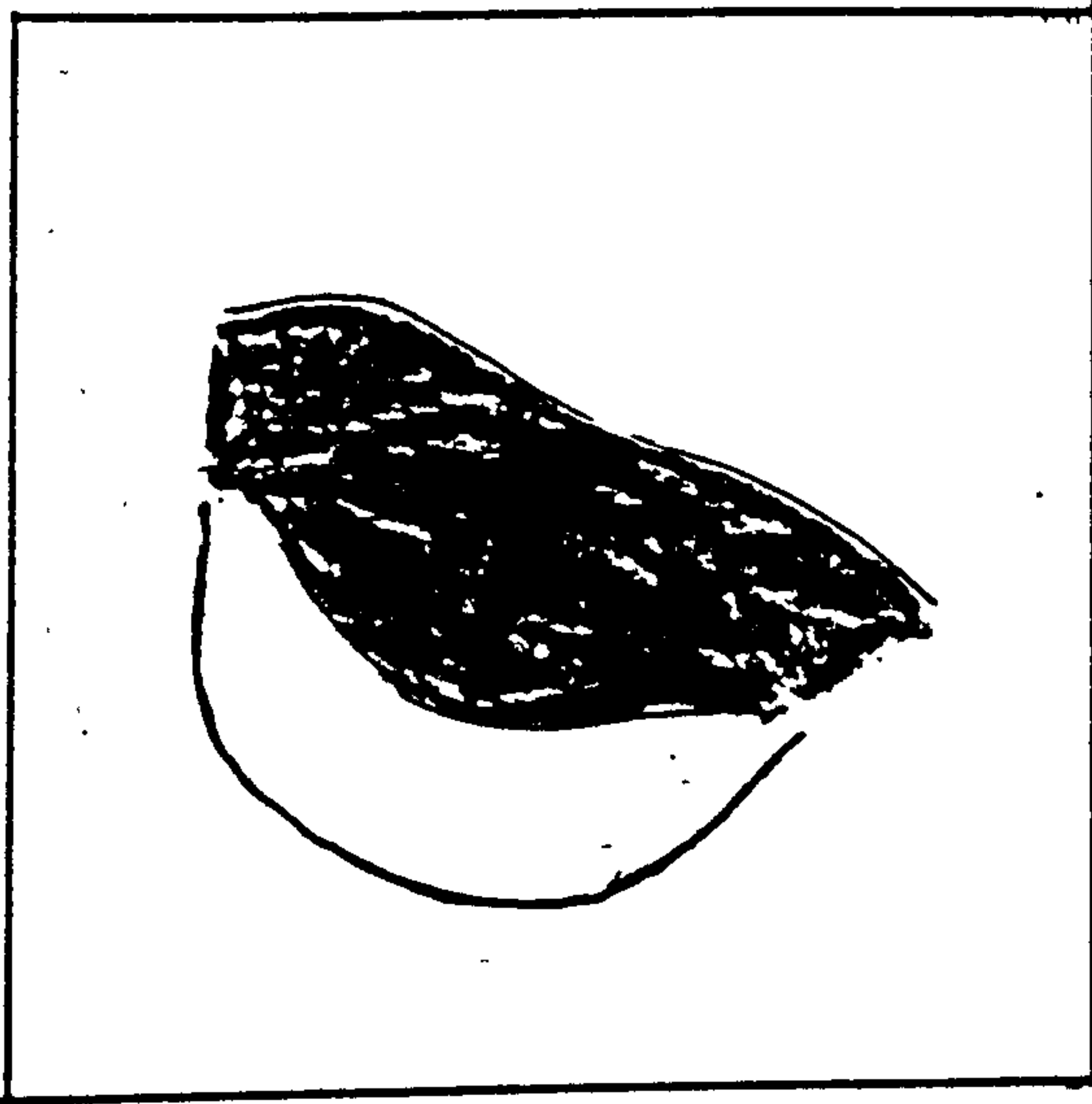


c. /s/ in /se:f/ (SA)

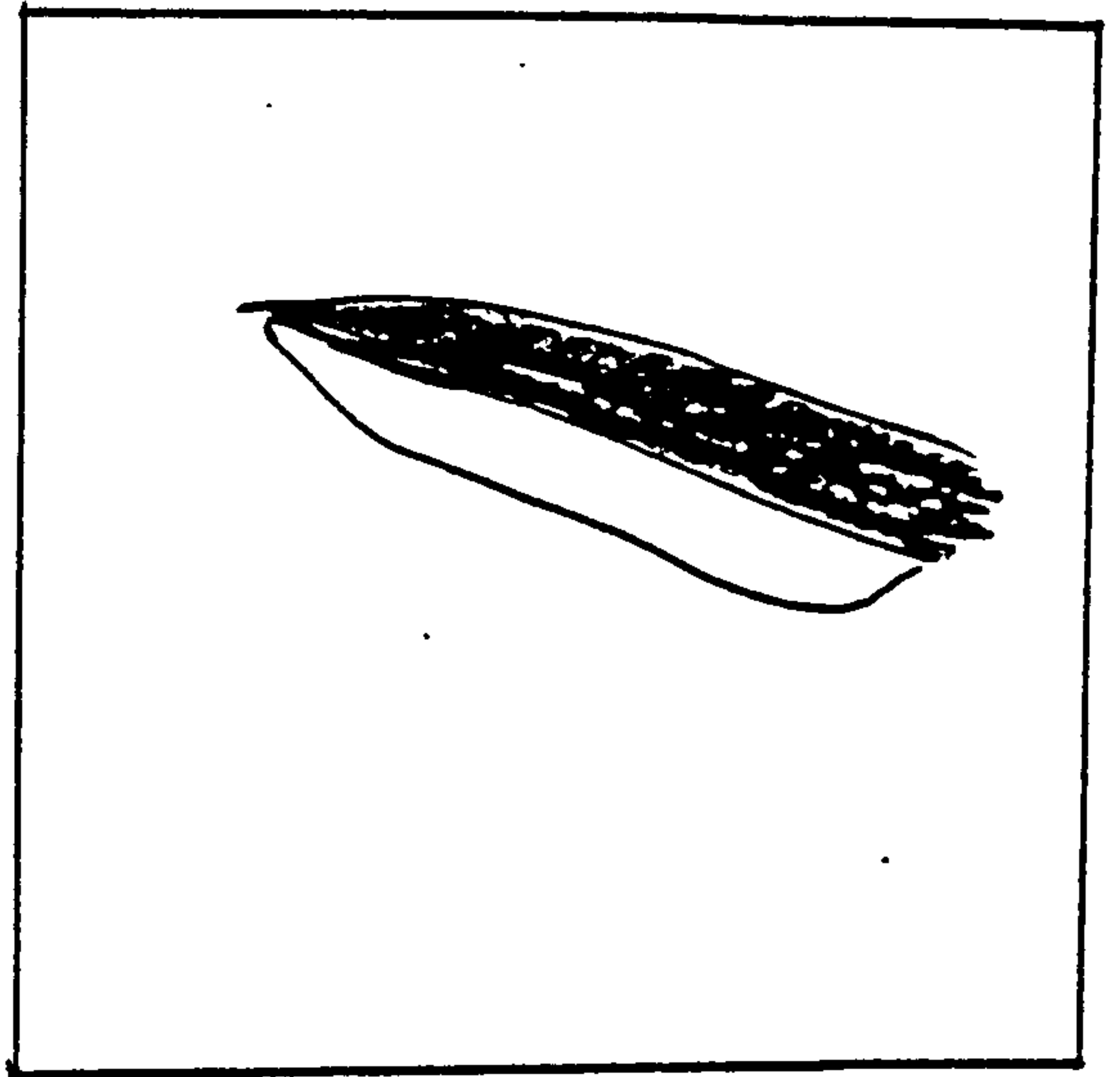


d. /S/ in /Se:f/ (SA)

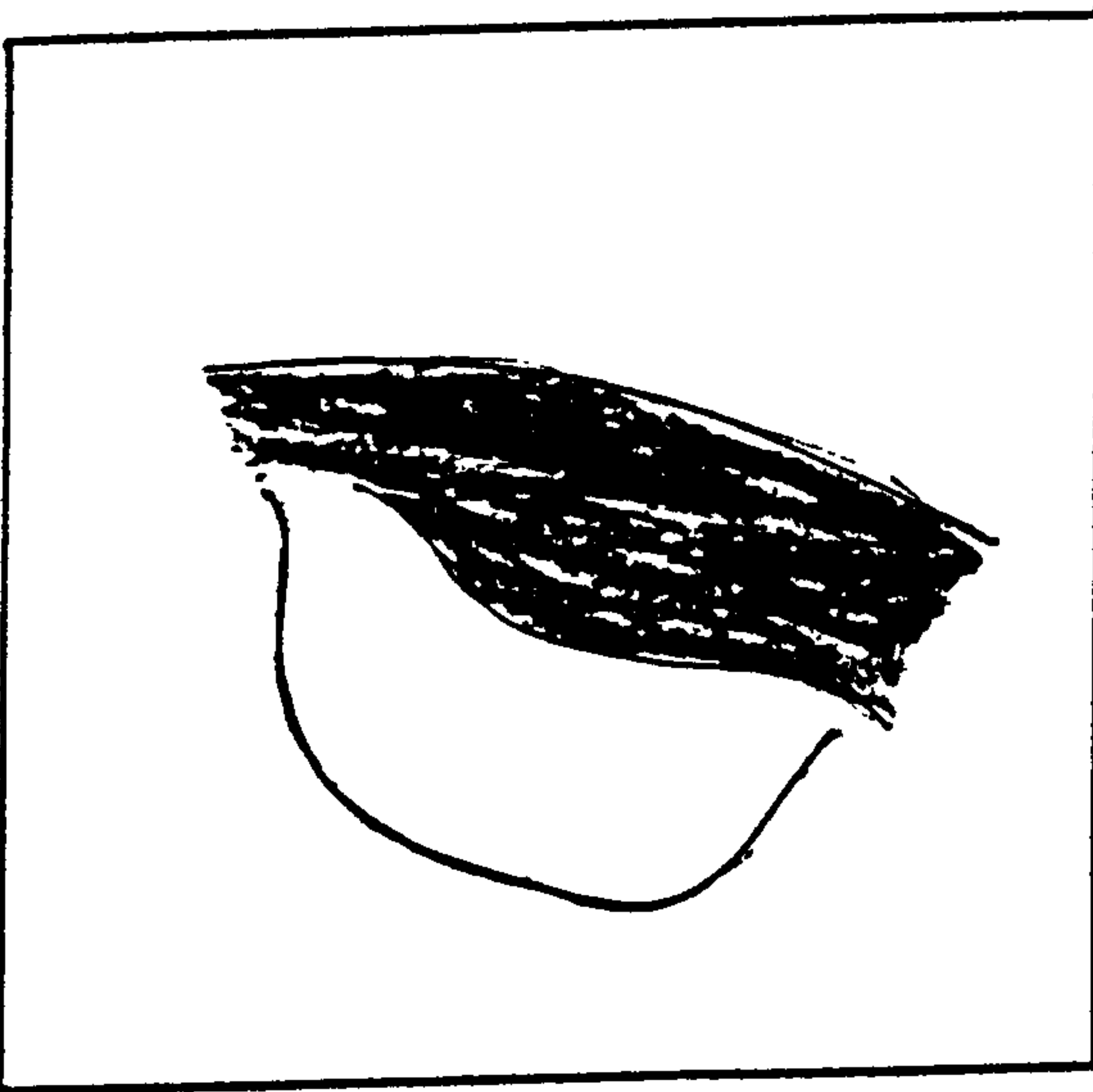
Figure 6.18



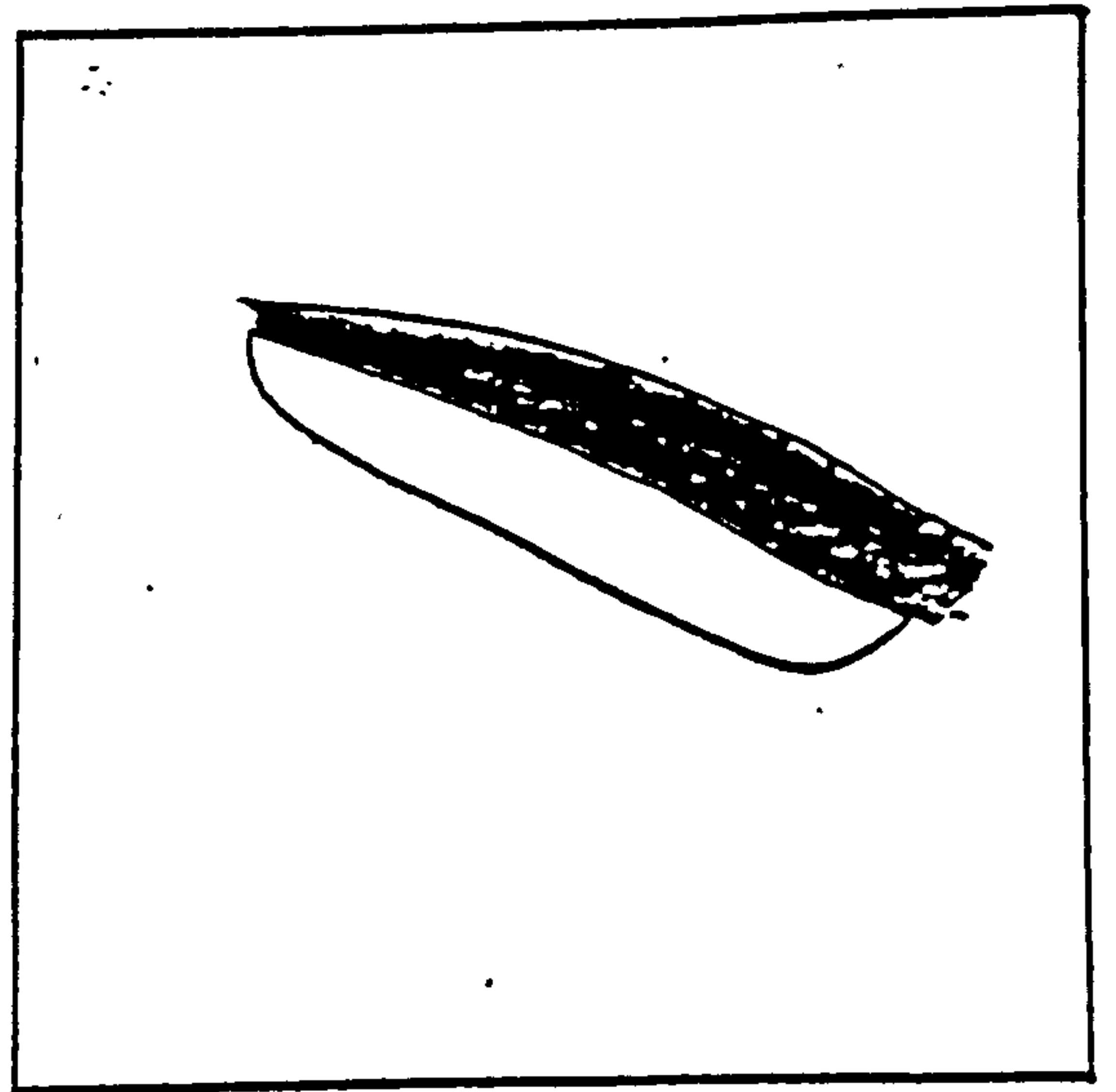
a.



b.



c.



d.

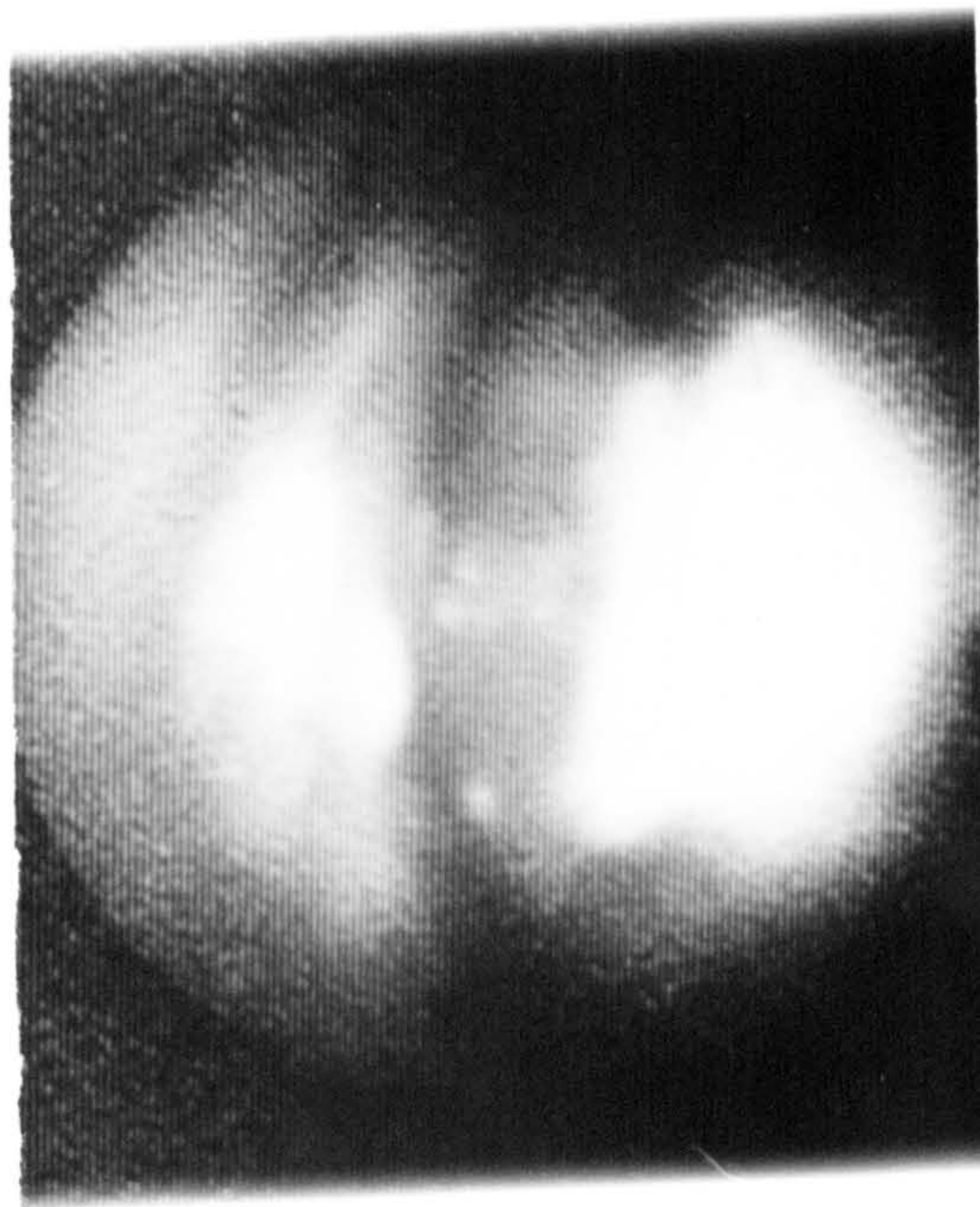
Sketches of Figure 6.18

lateral xeroradiogram (1982), of her Iraqi subject's /T/ in /Ti:n/, where a uniquely maximum constriction occurs. No previous radiographic views of pharyngealized sounds had showed this.

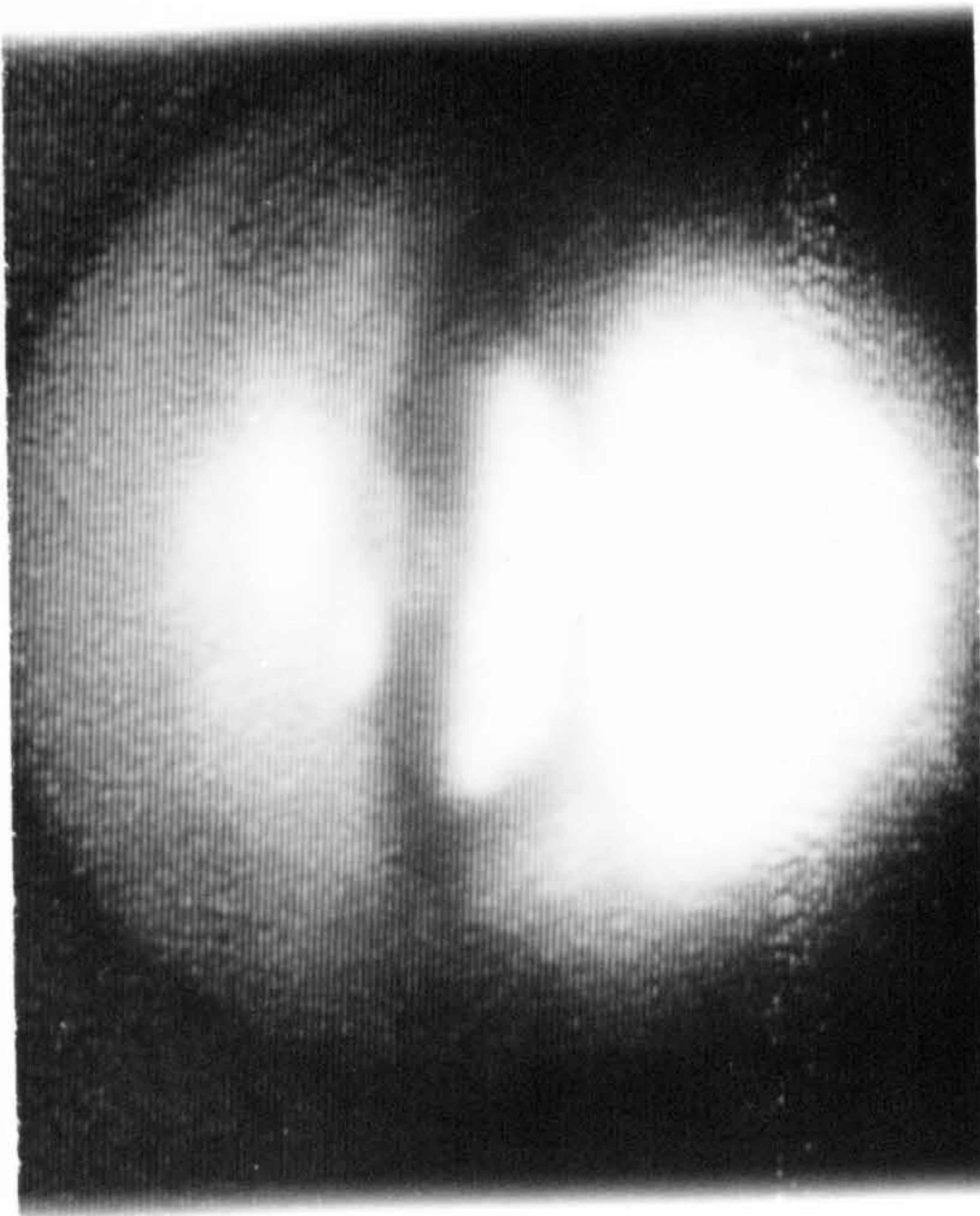
The example of the pharyngealized consonants /T/ and /S/ in /Ta:b/ and /Se:f/ as said by WL, Figure 6.19.a and d. respectively differ from those of SA in the amount of retraction of the epiglottis and the degree of uncurling of its upper edge, and also in the slight contraction of the side walls of the pharynx, which does not appear in these photographs. The upper edge of the epiglottis is even less uncurled, probably in anticipation of the following vowel /e:/, which requires a higher position for the tongue. Though the epiglottis does not move forward in the pharynx following the vowel, it almost appears to try to compensate by stretching its upper edge. It seems fairly certain that the movement forward and upward of the tongue is in anticipation of the following vowel /e:/; this eases the backward and downward force exerted by its root on the epiglottis (which causes the upper edge to uncurl).

The position of the epiglottis in Figure 6.19.b of /a:/ in /Ta:b/ of subject (WL), is similar to those of subject (SA) of the pharyngealized consonants. The epiglottis is retracted close to the back wall of the pharynx,

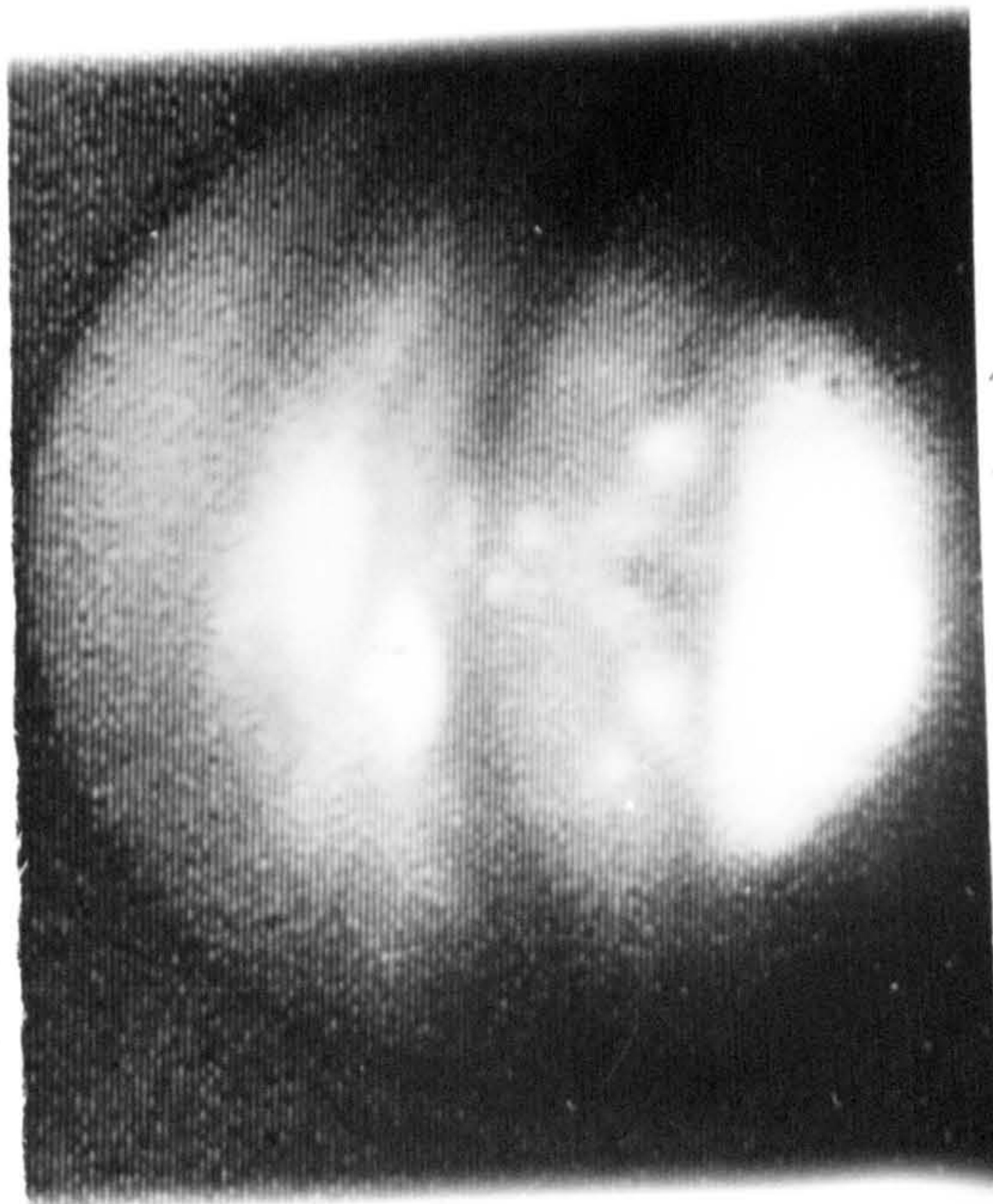
Figure 6.19



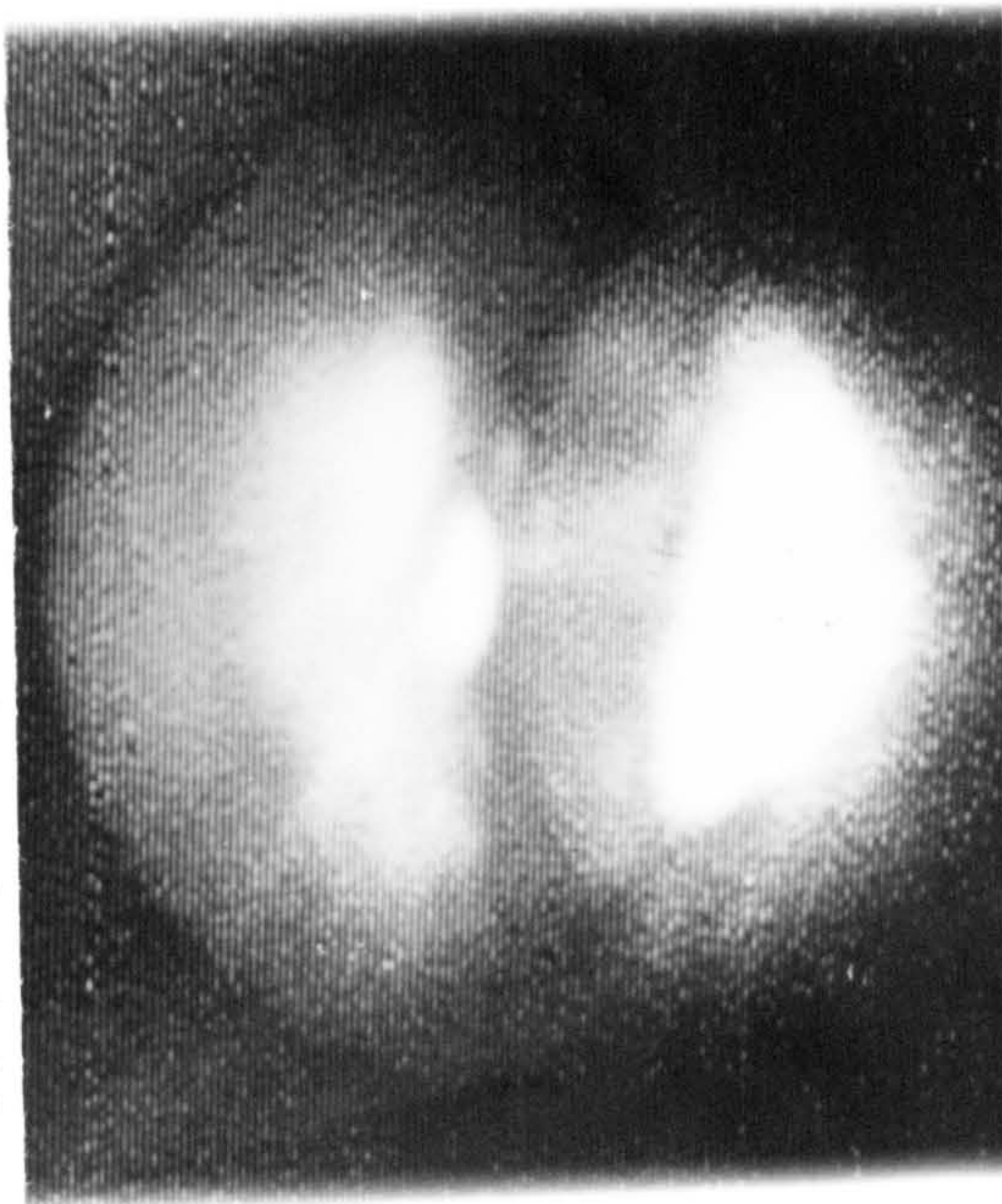
a. /T/ in /Ta:b/ (WL)



b. /a:/ in /Ta:b/ (WL)

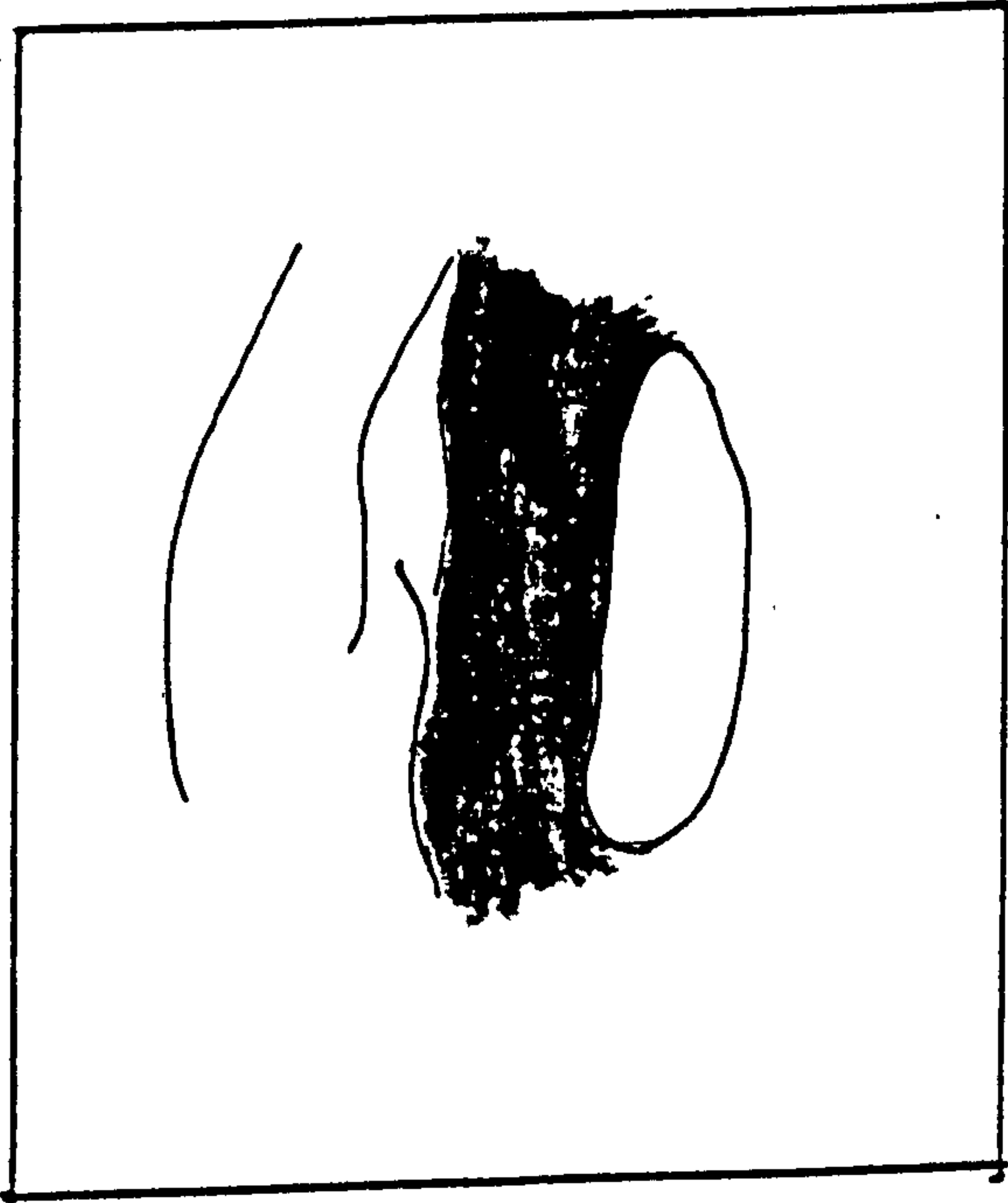


c. /s/ in /se:f/ (WL)

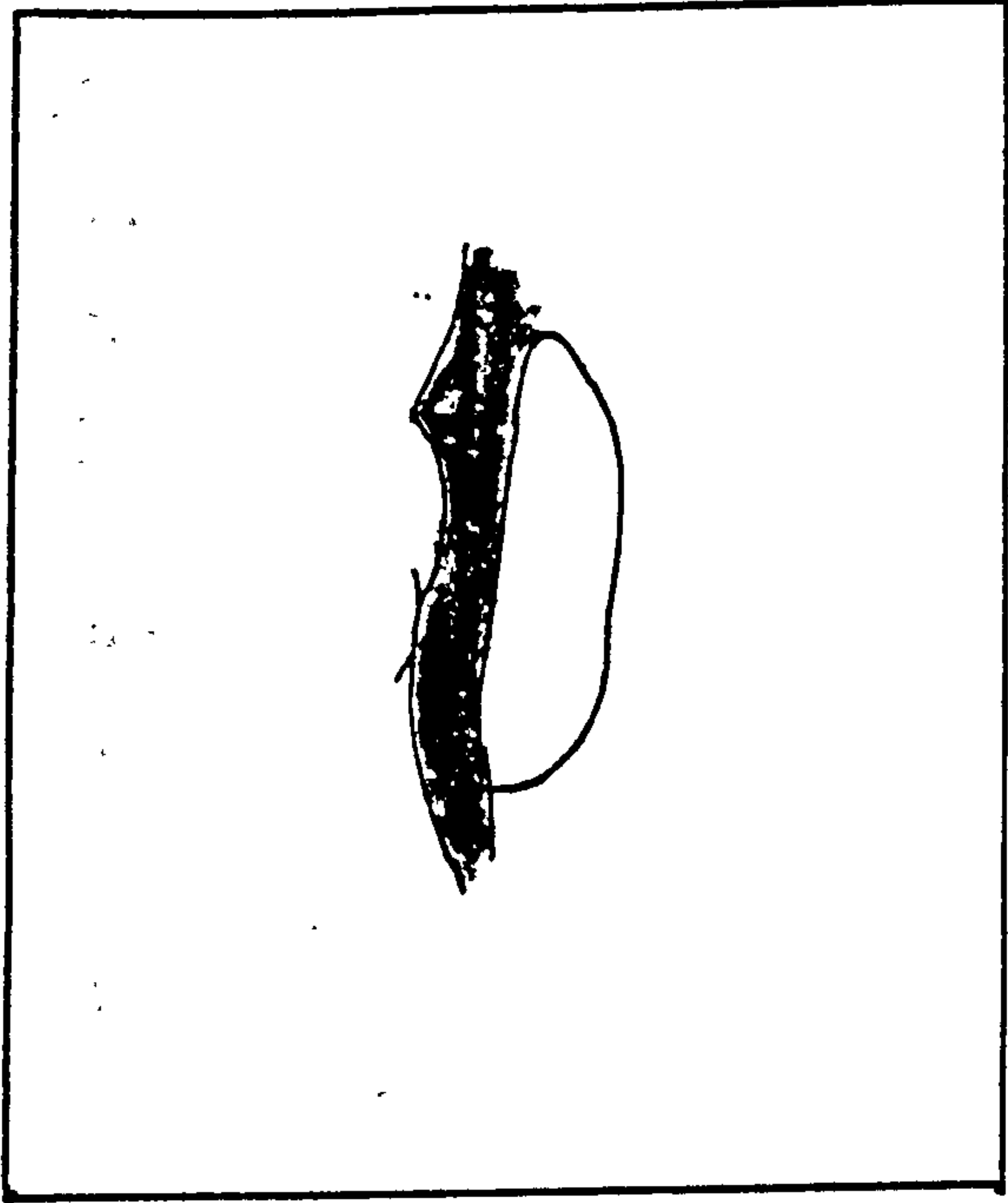


d. /S/ in /Se:f/ (WL)

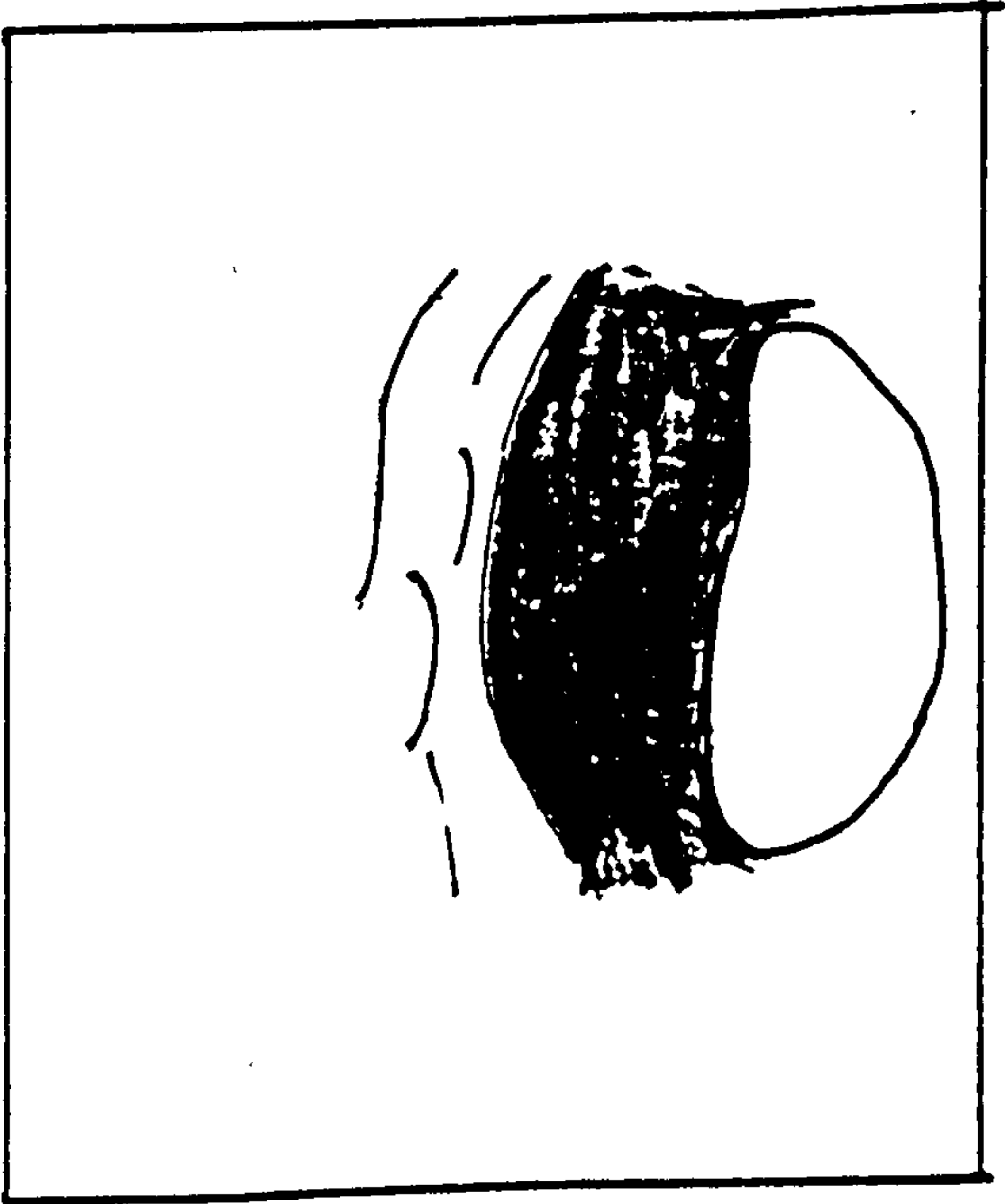
a.



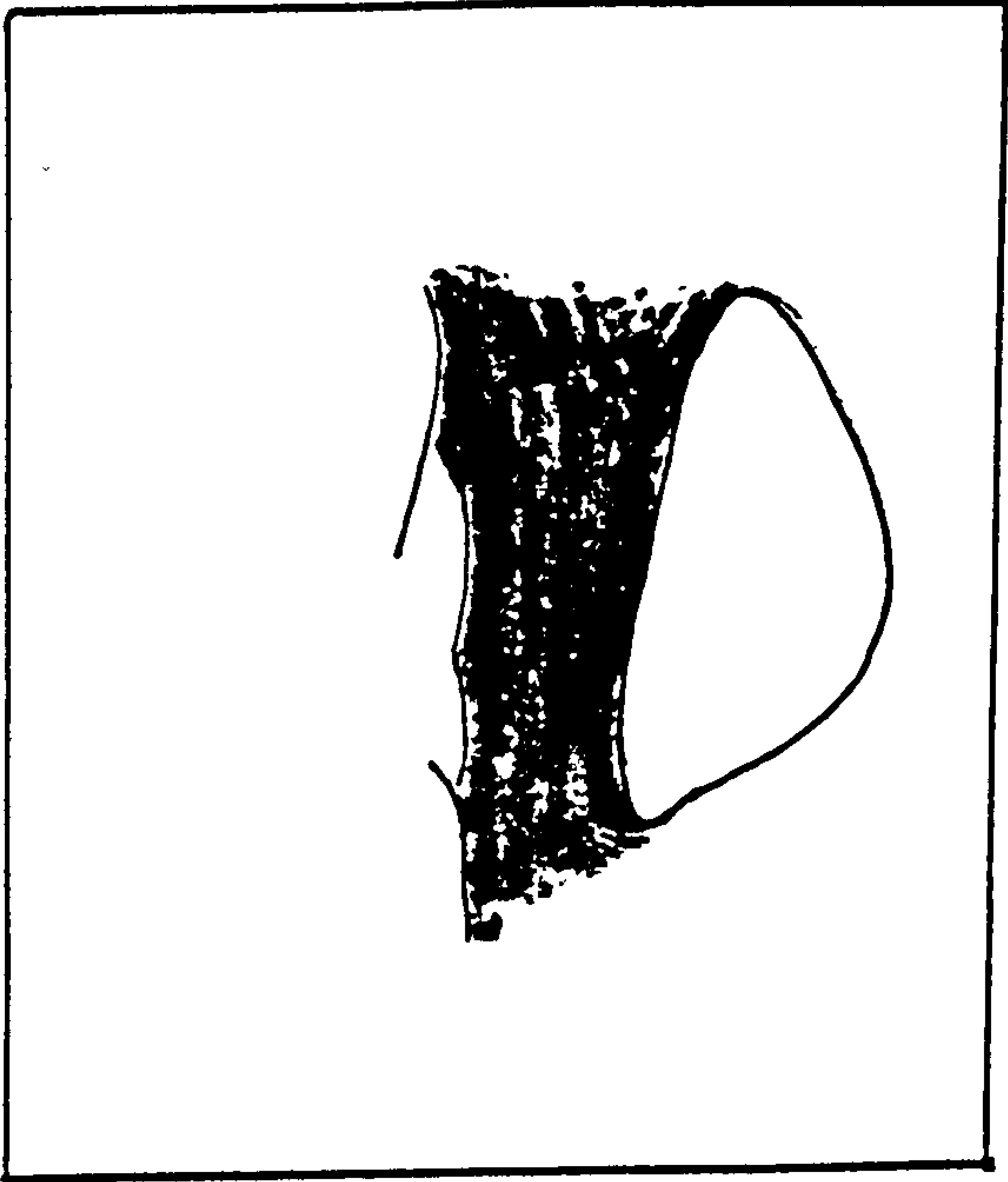
b.



c.



d.



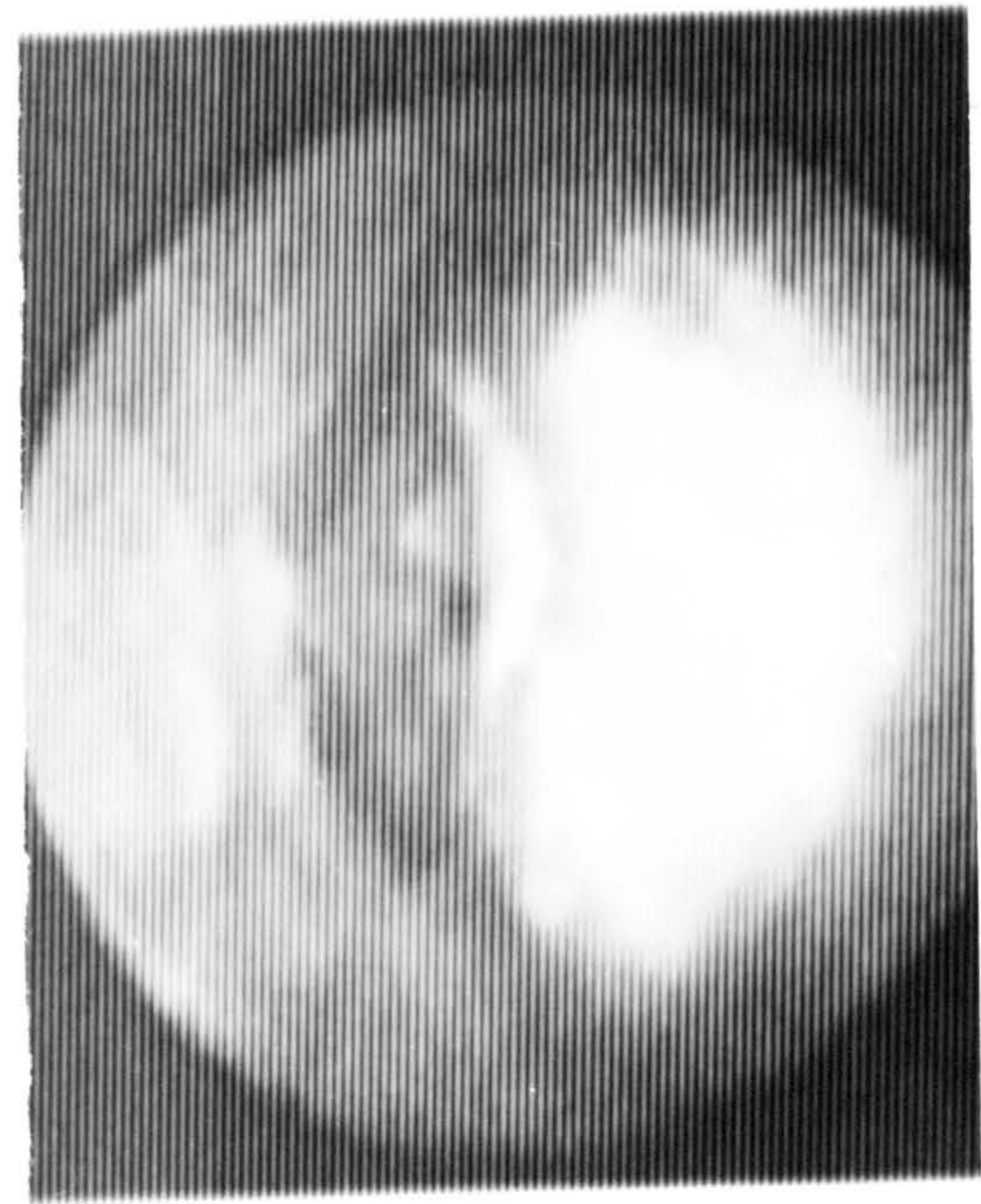
Sketches of Figure 6.19

and its tip is uncurled. The tongue also is retracted touching the upper edge of the epiglottis.

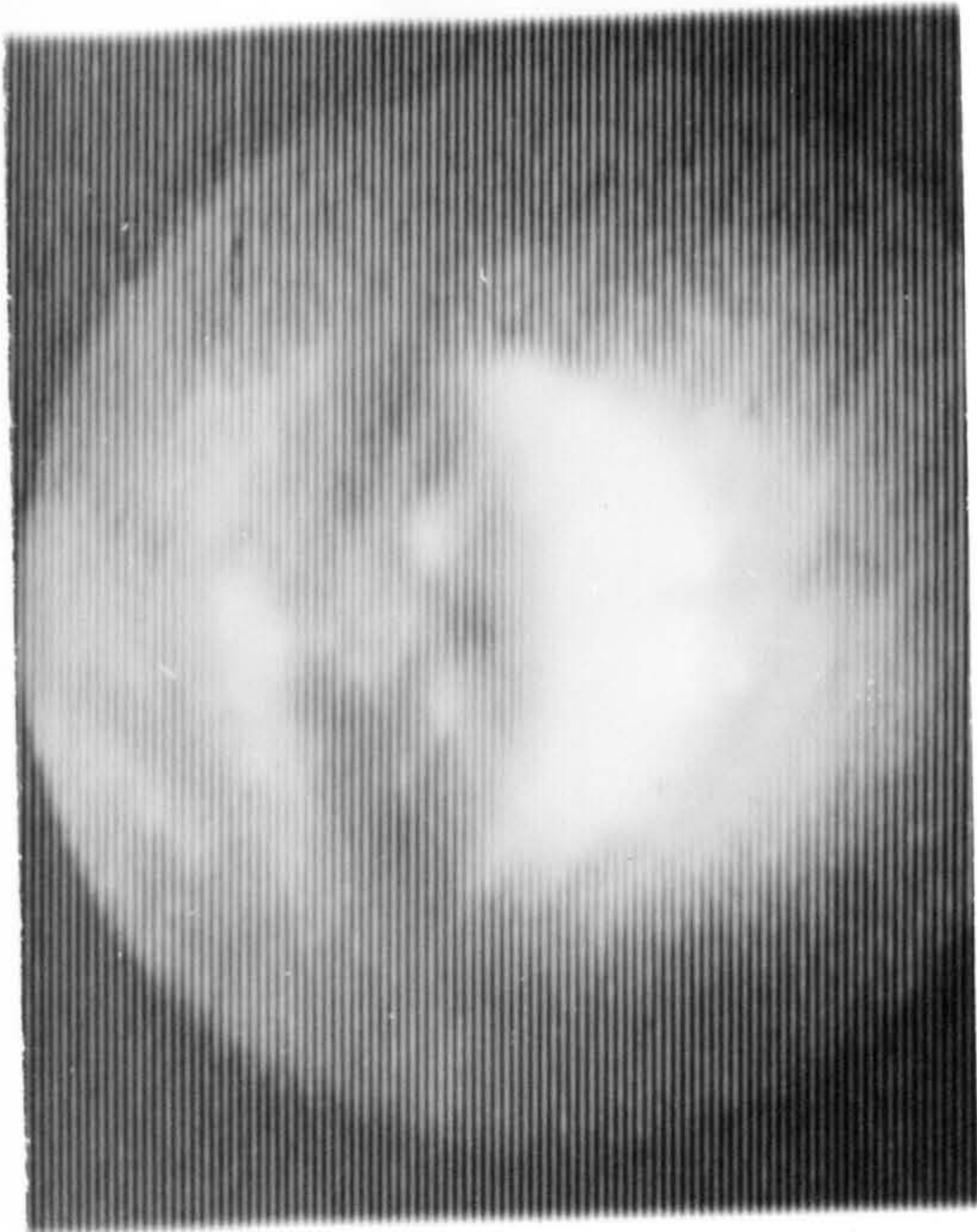
Even though the pharyngealized lateral /L/ is not represented in the Arabic orthography by a special letter like /T D S Ø/, one is justified in considering it a pharyngealized consonant on the ground that radiographic and endoscopic investigation of /L/ show all the physiological characteristics of the pharyngealized consonants.

The four examples of Figure 6.20 give an endoscopic view of the pharynx during the articulation of /LL/ in /waLLa/, (a), medial /l/ in /dala:l/ (b), final and medial /l/ in /Dala:l/ (c), and (d) respectively. The medial /l/ in /dala:l/ shows a similar position to the 'at rest' position. The other three examples show the characteristic features of the pharyngealized sounds as manifested in the articulation of FL, mainly brought about by the great constriction in the vallecula area by the backward and downward movement of the tongue. The epiglottis, as if resisting both the pressure exerted by the root of the tongue and the force to push it towards the back wall of the pharynx tends to uncurl its tip. The opening between the epiglottis and the back wall of the pharynx is slightly narrower than that for the non-pharyngealized counterpart. There is also some lateral wall constriction, which clearly appears in

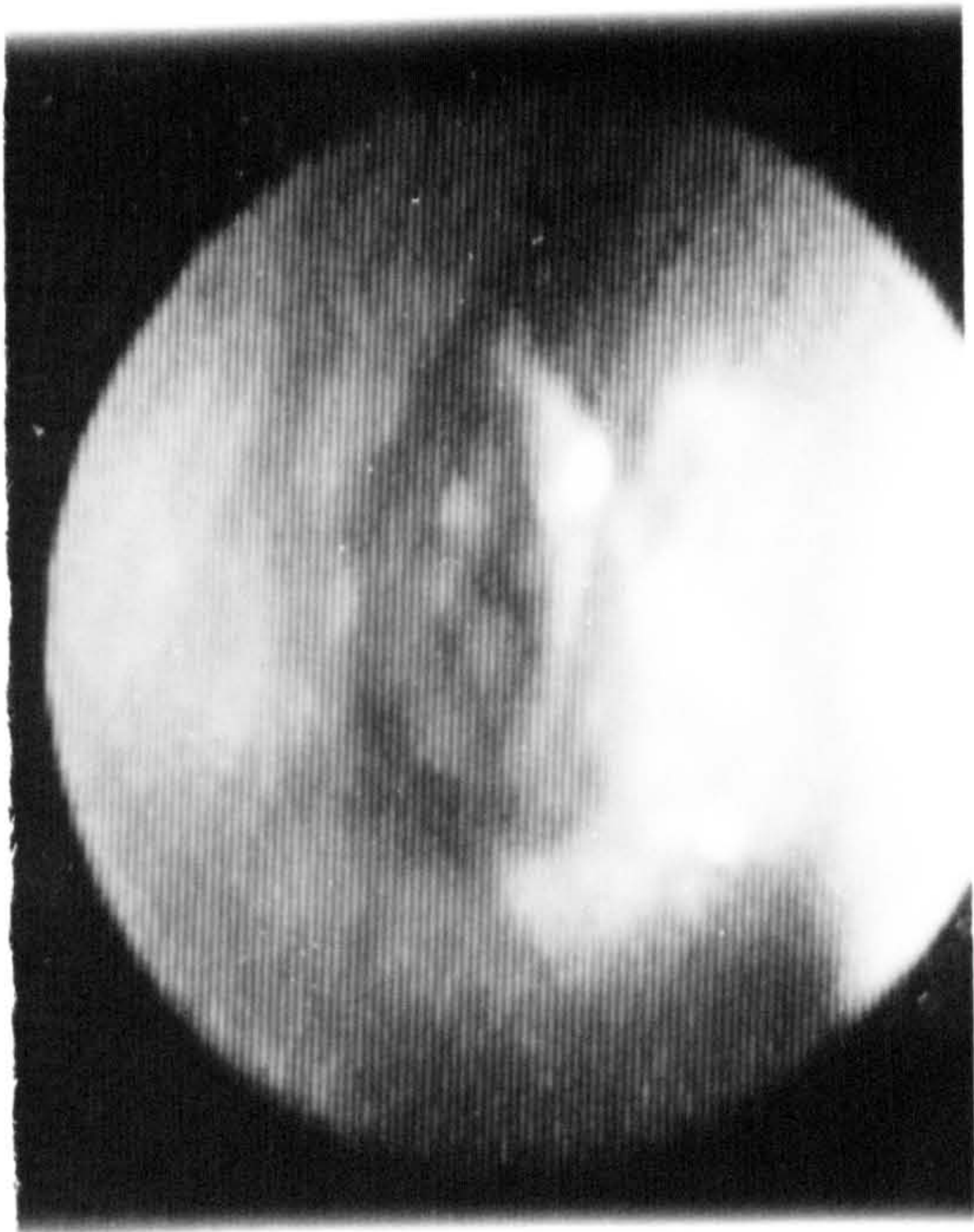
Figure 6.20



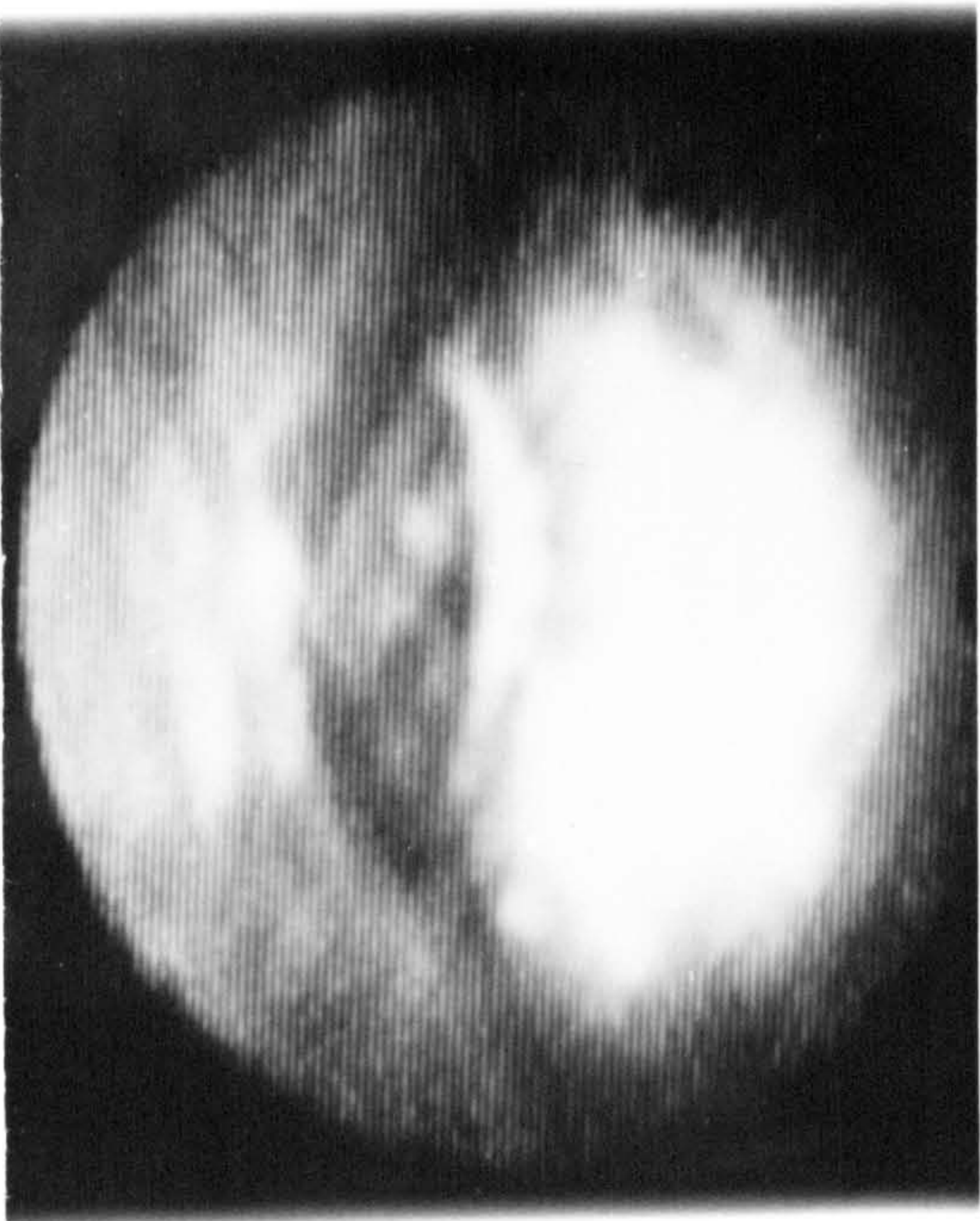
a. /IL/ in /waLLa/ (FL)



b. medial /l/ in /dala:l/ (FL)

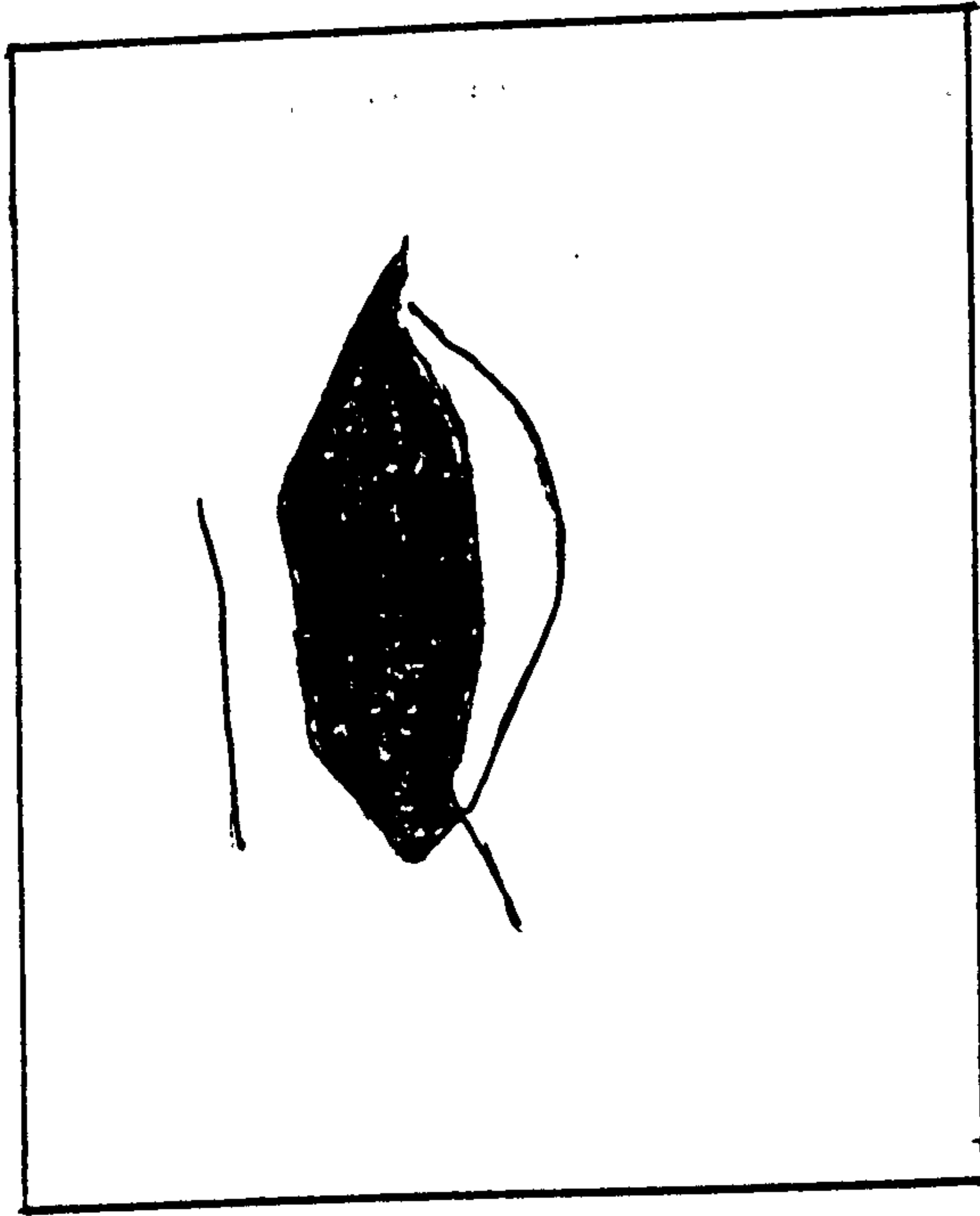


c. Final /l/ in /Dala:l/ (FL)

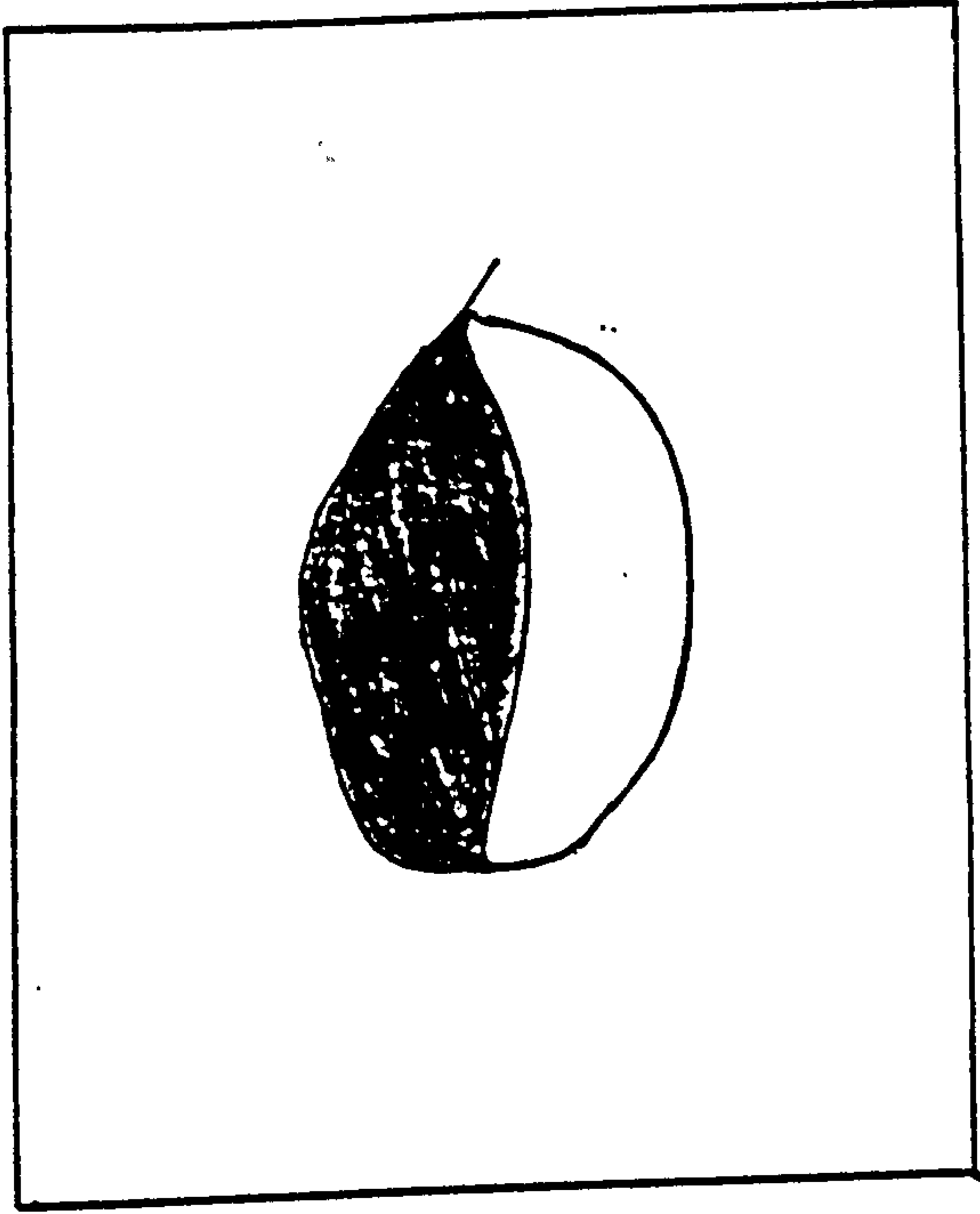


d. medial /l/ in /Dala:l/ (FL)

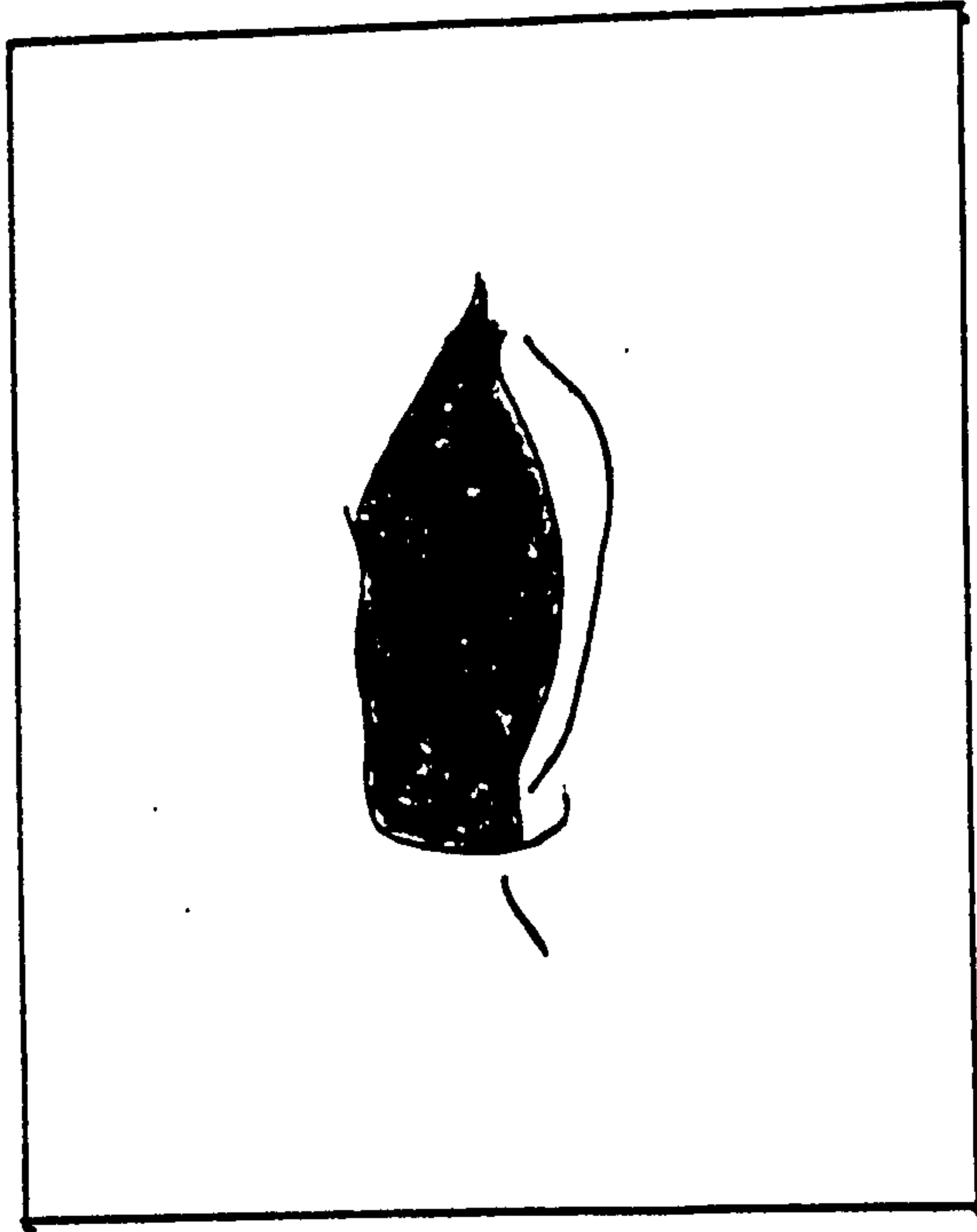
a.



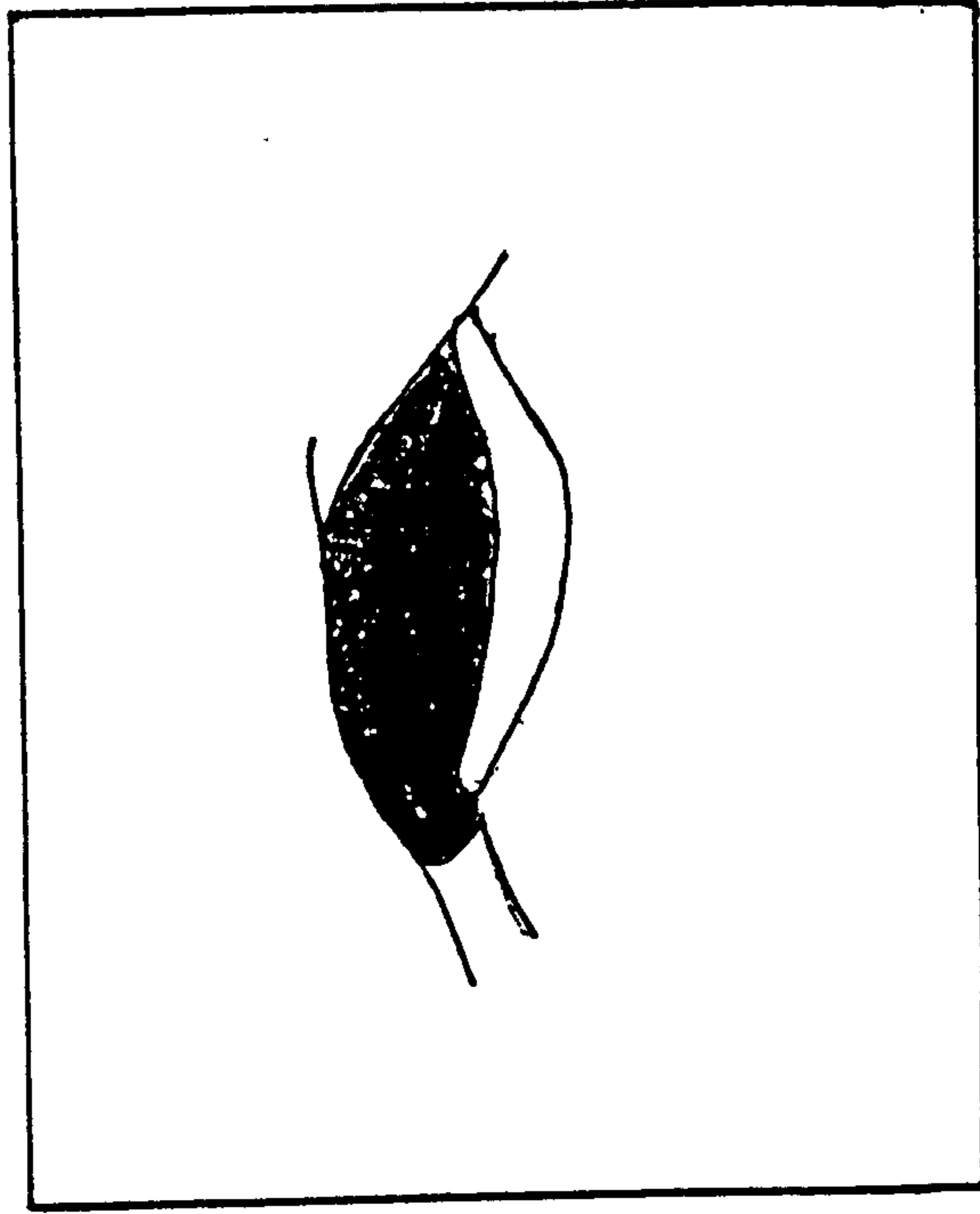
b.



c.



d.



Sketches of Figure 6.20

Figure 6.21



a. /ZZ/ in /gaZZa/ (FL)



b. Final /a/ in /gaZZa/ (FL)

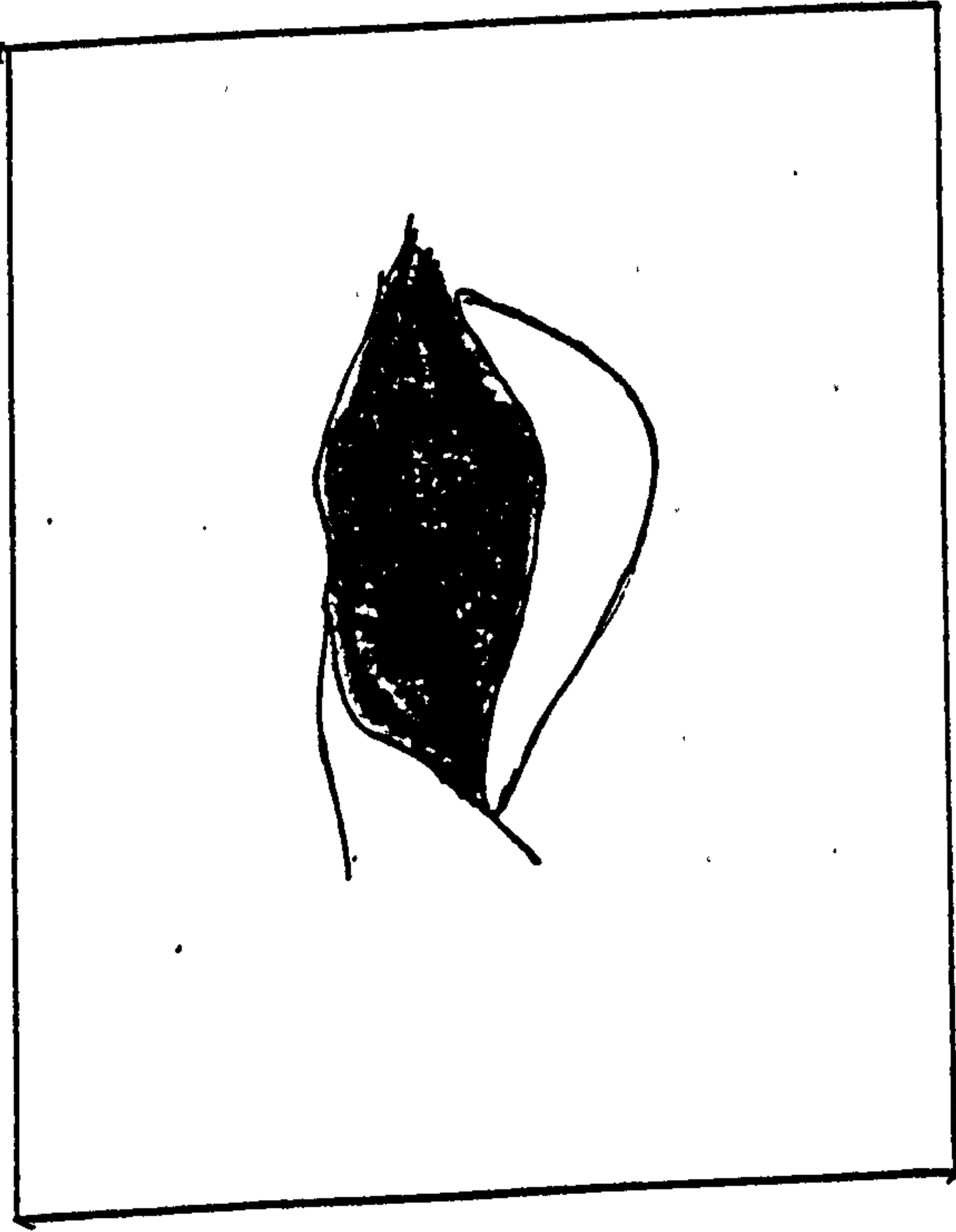


c. /i:/ in /Di:g/ (FL)

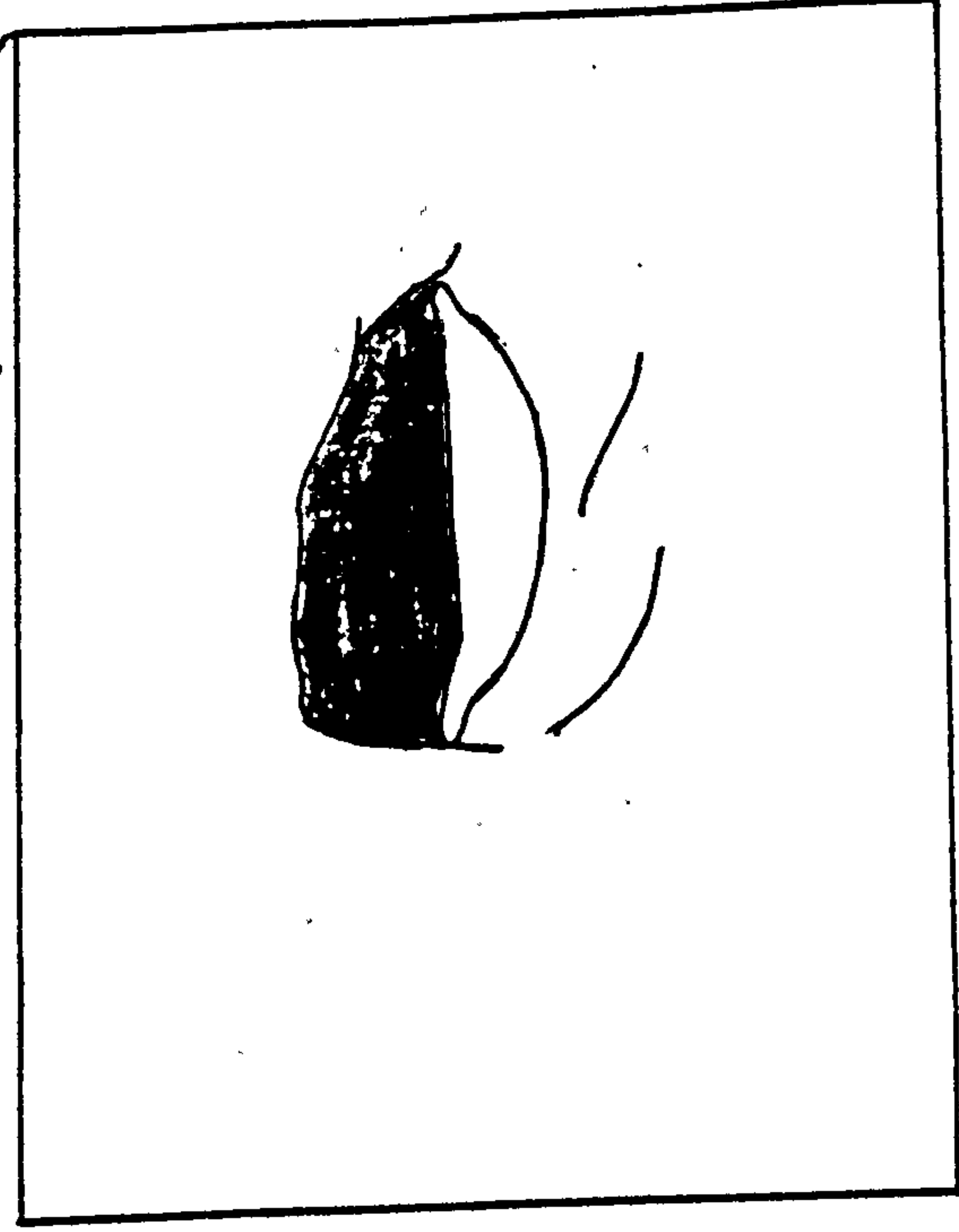


d. /rr/ in /garr/ (FL)

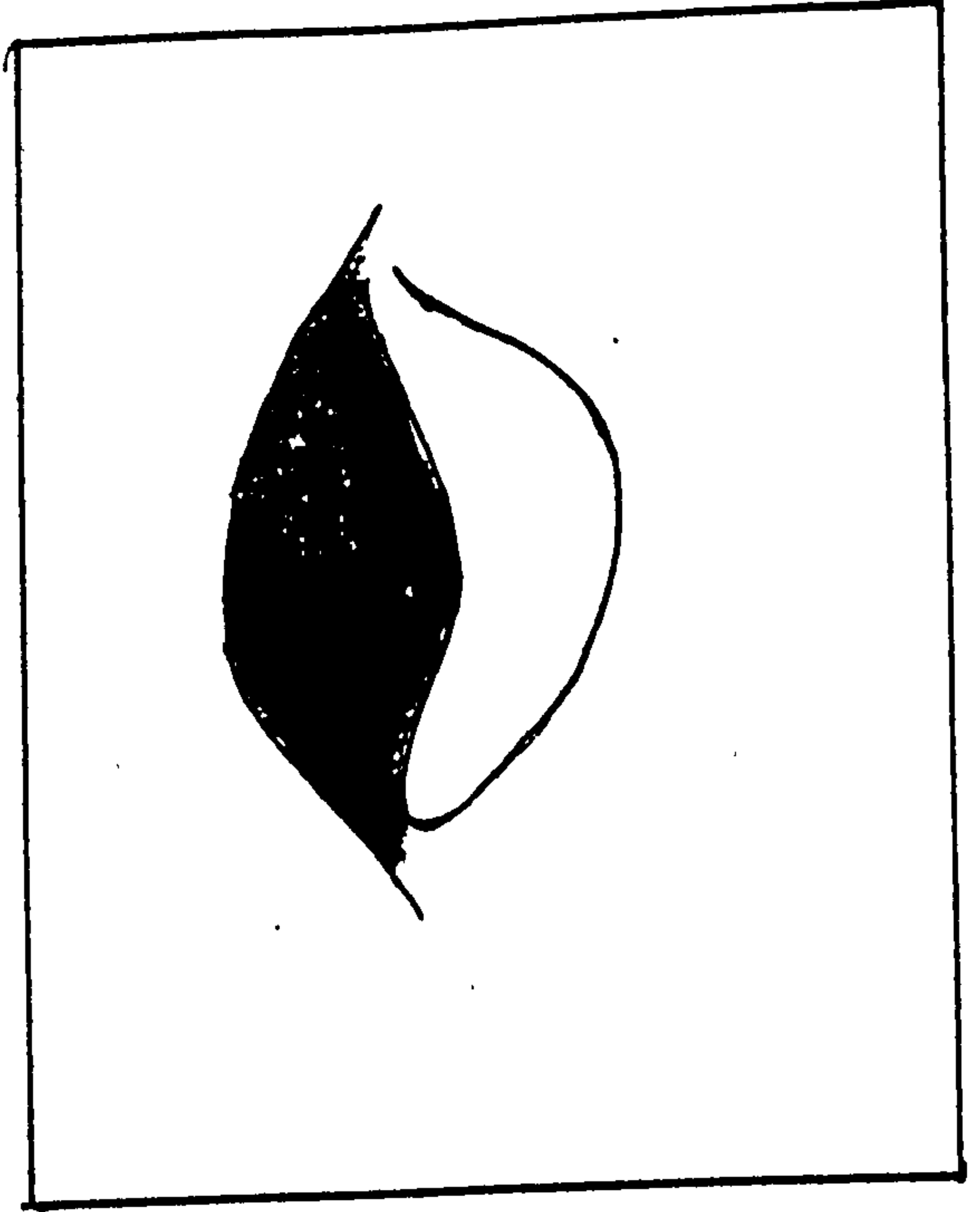
a.



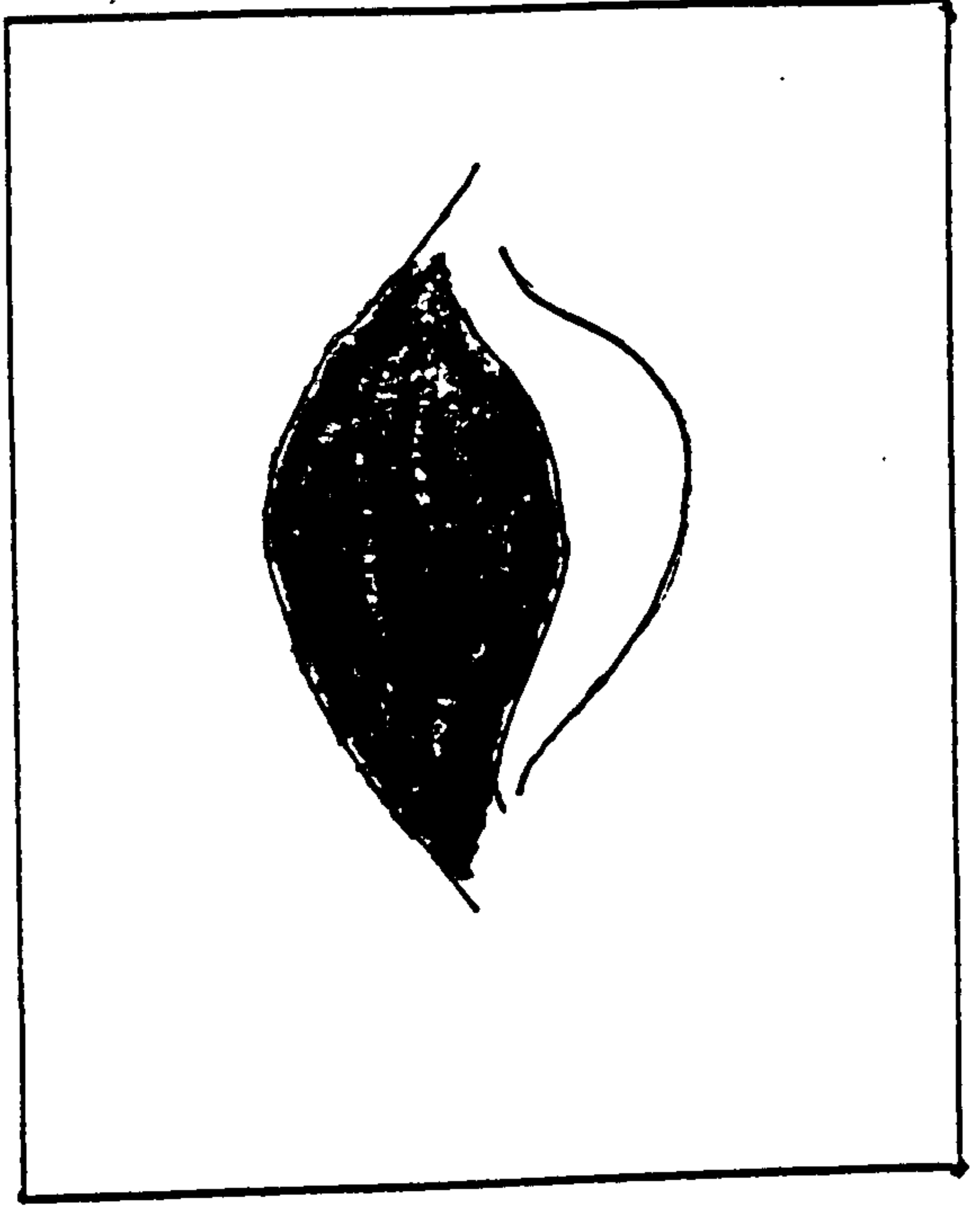
b.



c.



d.



Sketches of Figure 6.21

a. of /ll/ in /waIlLa/. The similarity of /l/ in c. and d. show that /D/ in /Da:la:l/ spreads its coarticulatory effect over the following segments and ~~across~~ syllable boundary (the presence of the adjacent /a:/, undoubtedly contributing to this coarticulatory effect). The front vowel, /i:/, for instance, in this position would have prevented this coarticulatory effect. Figure 6.21.c shows /Di:g/ during the articulation of the vowel /i:/. Even though this vowel is adjacent to the pharyngealized consonant /D/, the characteristic features of this consonant are not manifested in /i:/. There is no coarticulatory effect of /D/ on /i:/, supporting the xeroradiographic evidence of /i:/ in /Ti:n/, Figure 6.4. Final /a/ in /gaZZa/, Figure 6.21.b shows the expected articulatory features of the pharyngealized consonants as seen through the endoscope; the retraction of the epiglottis, the uncurling of its tip and the retraction of the root of tongue. There is also a considerable constriction of the right lateral wall, which is also a characteristic feature of the pharyngeal consonants. The pharyngeal cavity is more constricted during /a/ than during /ZZ/, in the same word (Figure 6.21.a) where the opening between the epiglottis and the back wall of the pharynx is wide, but the upper edge of the epiglottis is slightly uncurled. There is also some lateral wall constriction. However, this view is most probably of /ZZ/ just before or after the articulators reach their target for /ZZ/. The

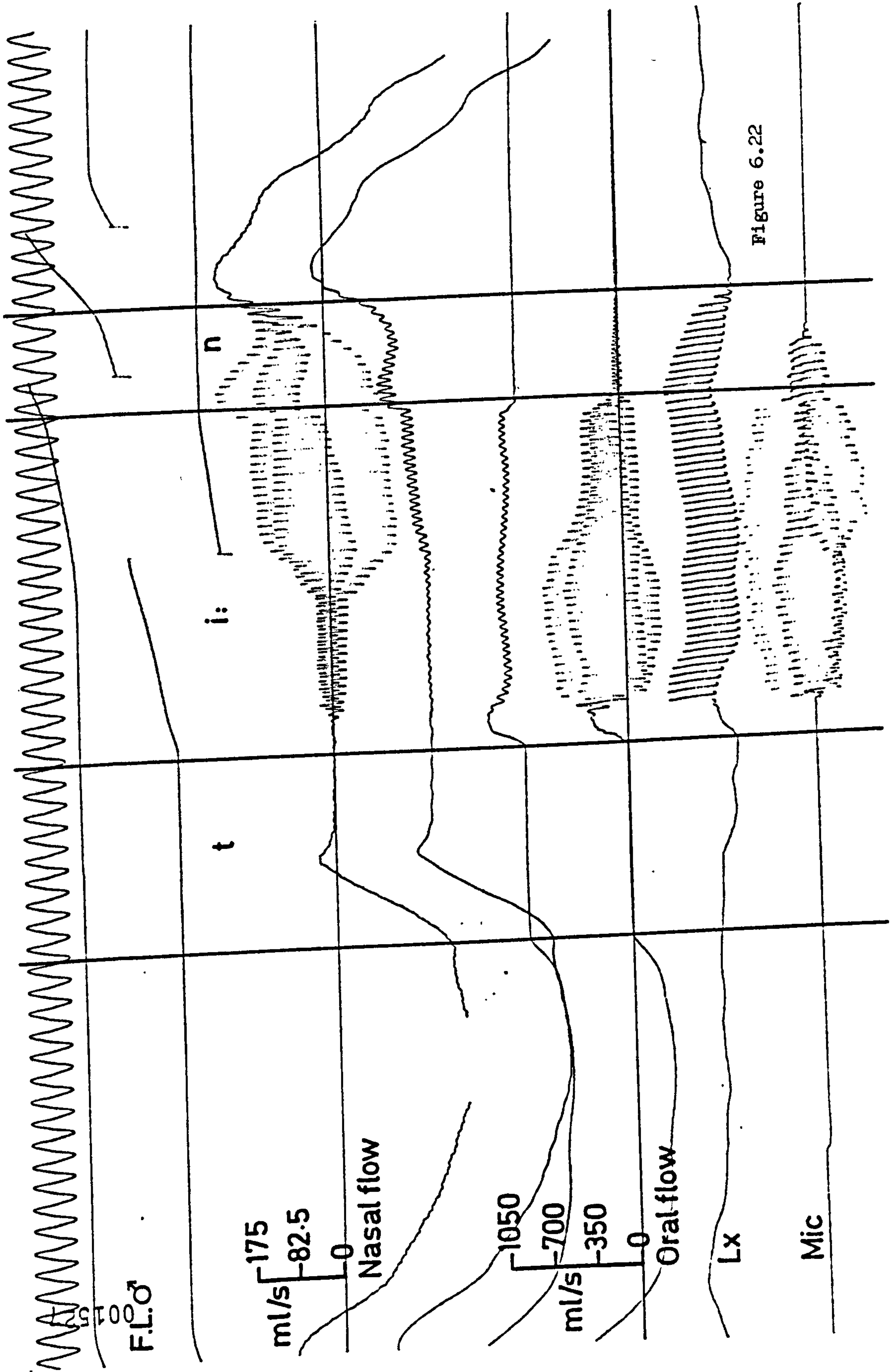


Figure 6.22

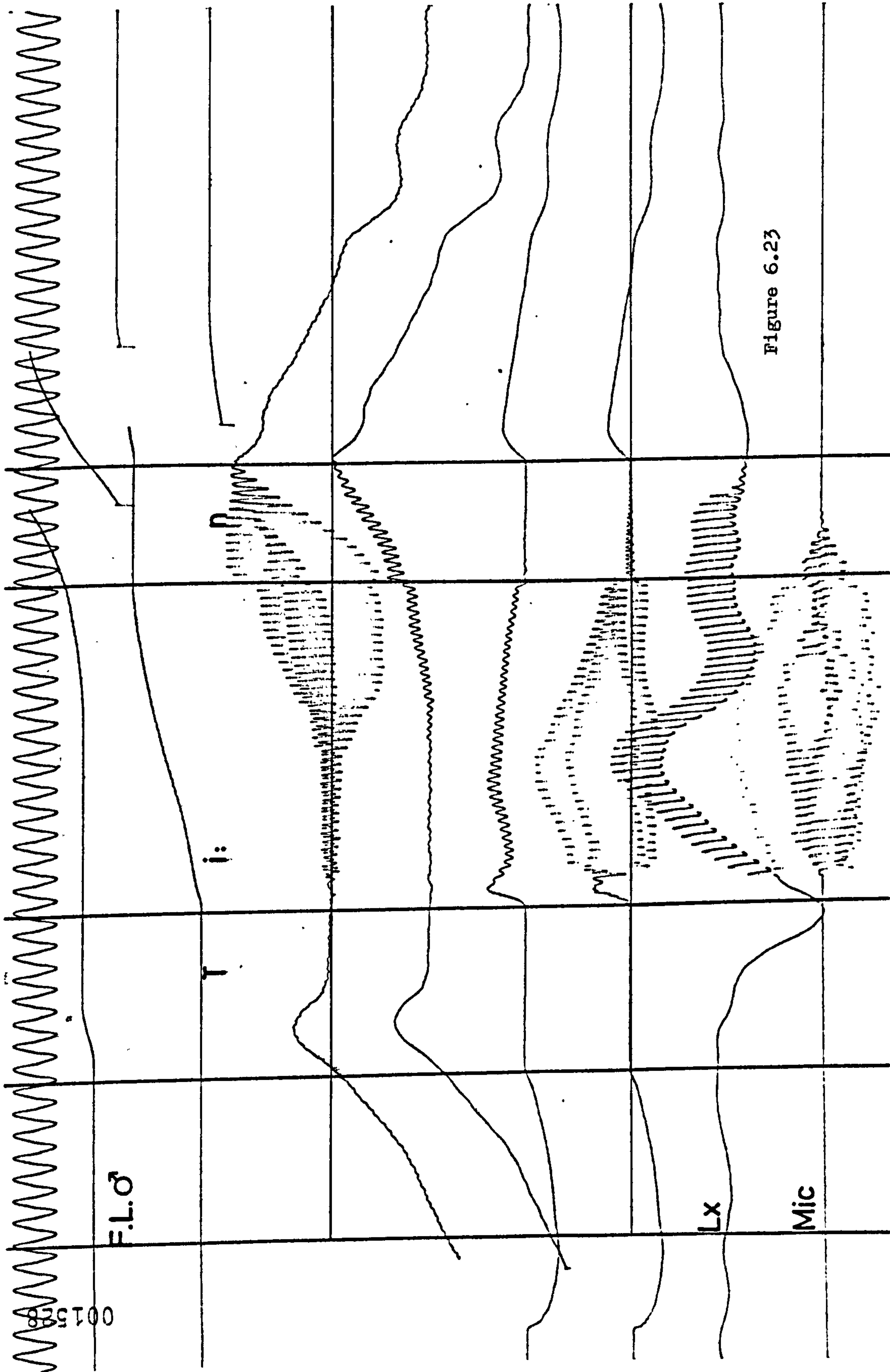


Figure 6.23

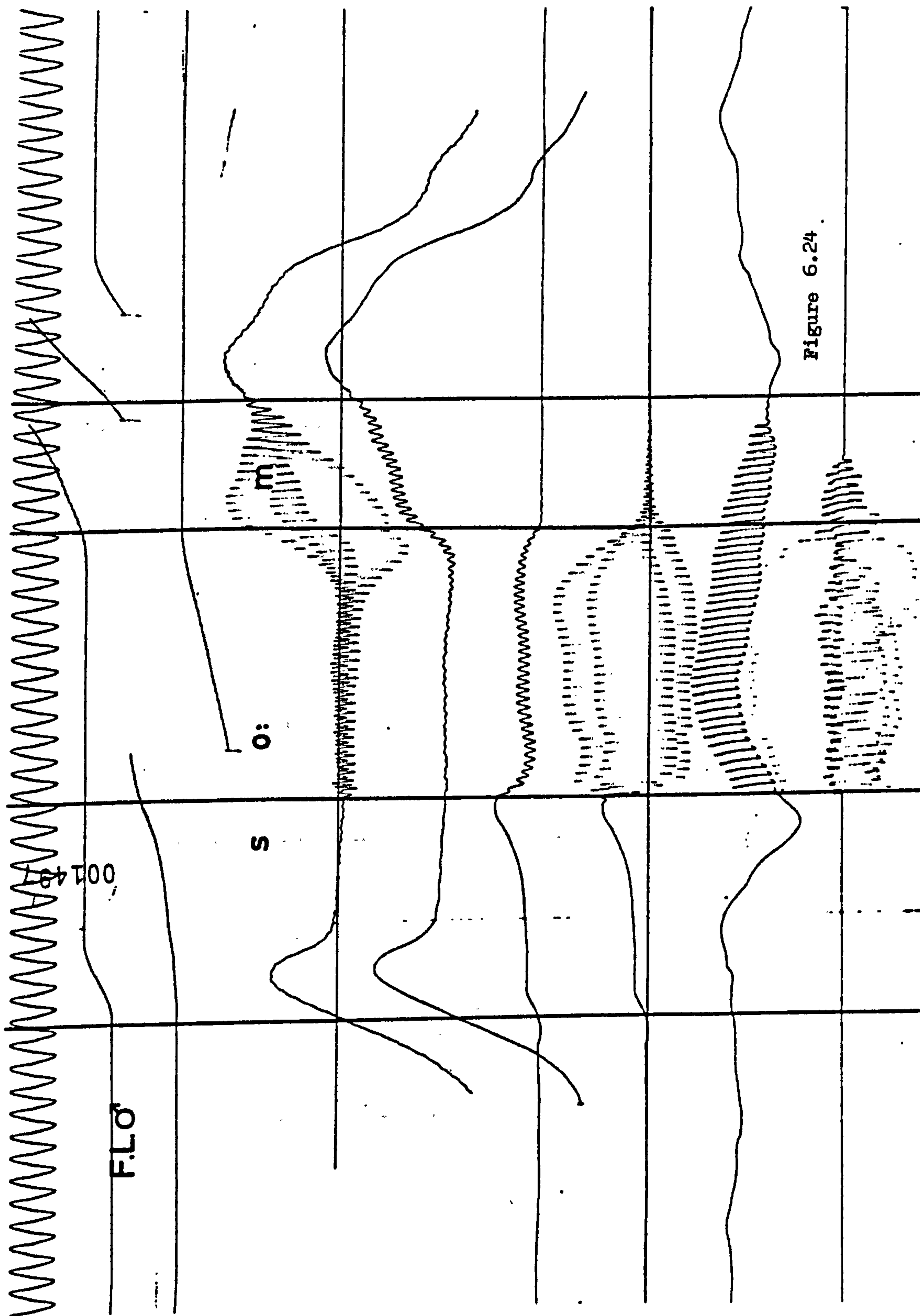


Figure 6.24

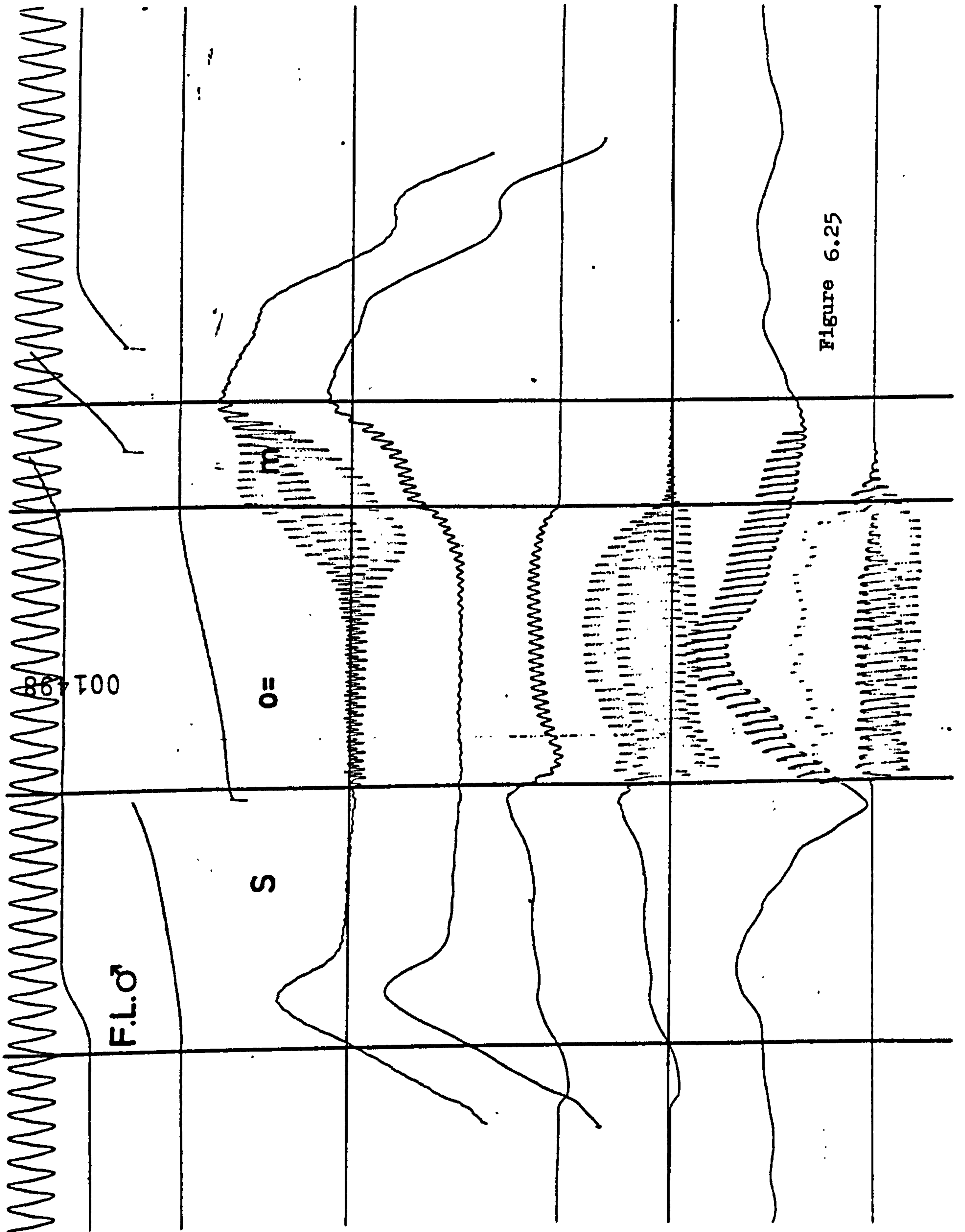


Figure 6.25

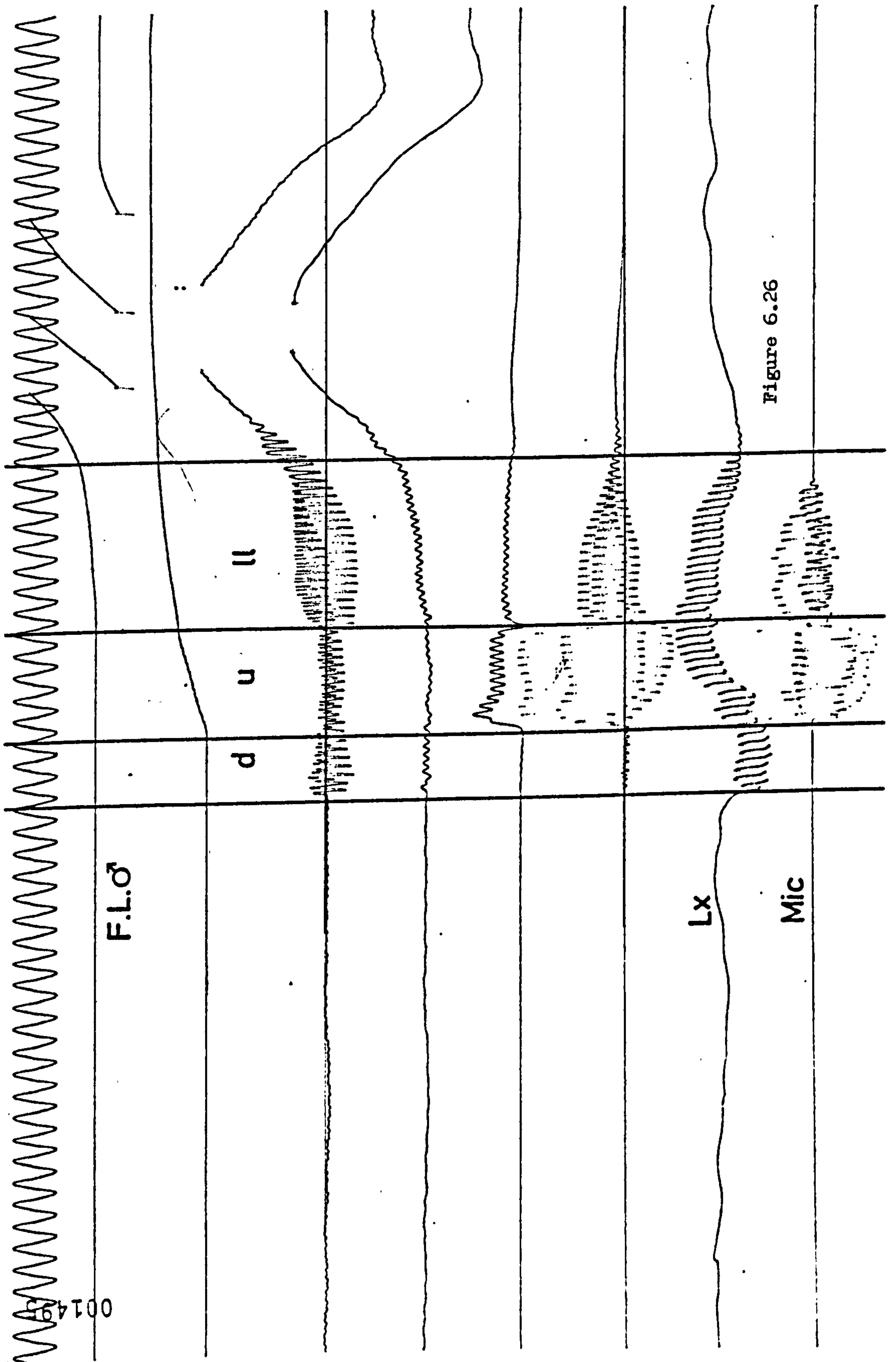


Figure 6.26

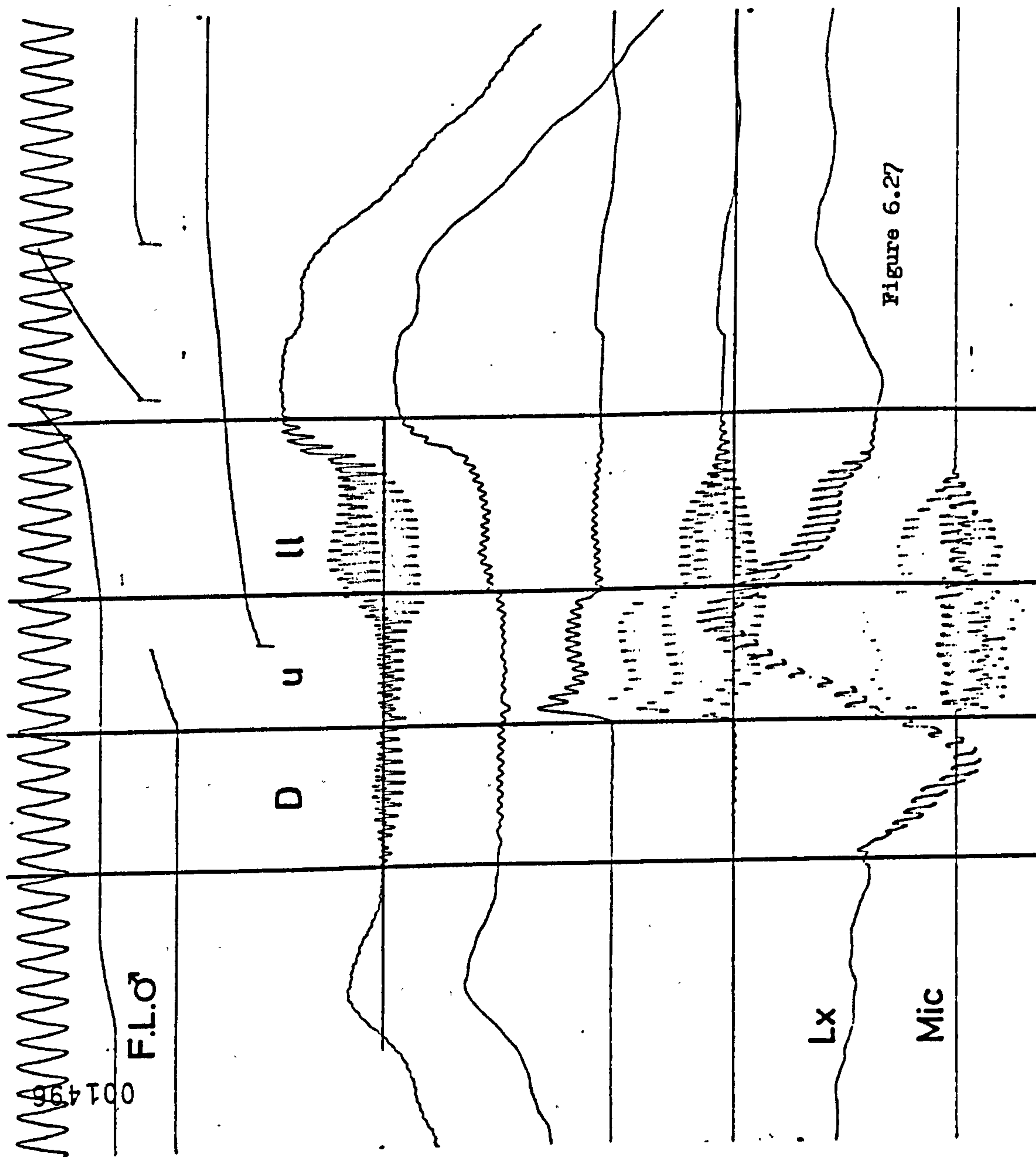


Figure 6.27

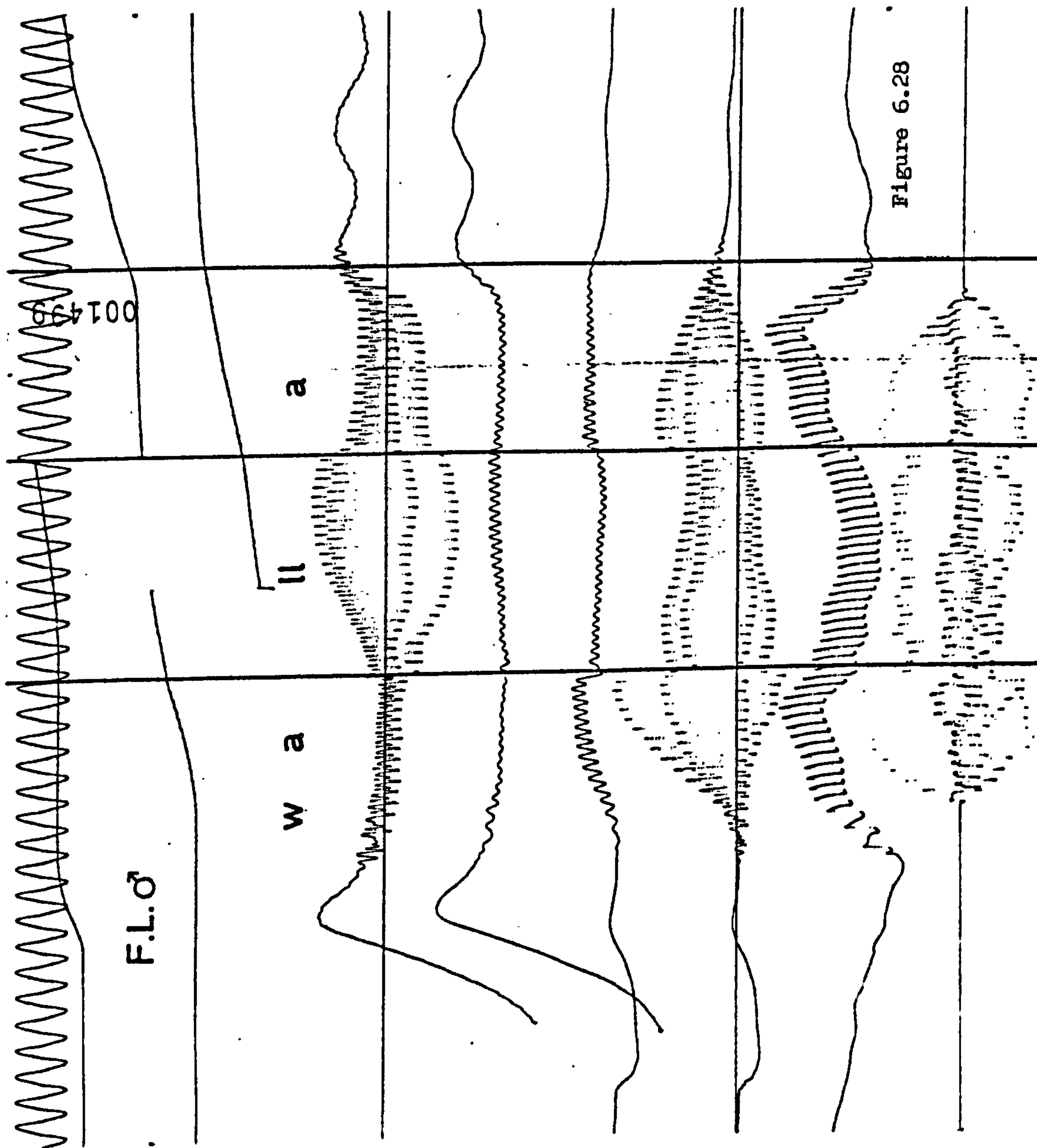
example of /rr/ in /garr/, Figure 6.21.d is very similar to some examples of the uvular consonants /X/ and /g/. The epiglottis is not retracted, and its upper edge is stretched forward and upward.

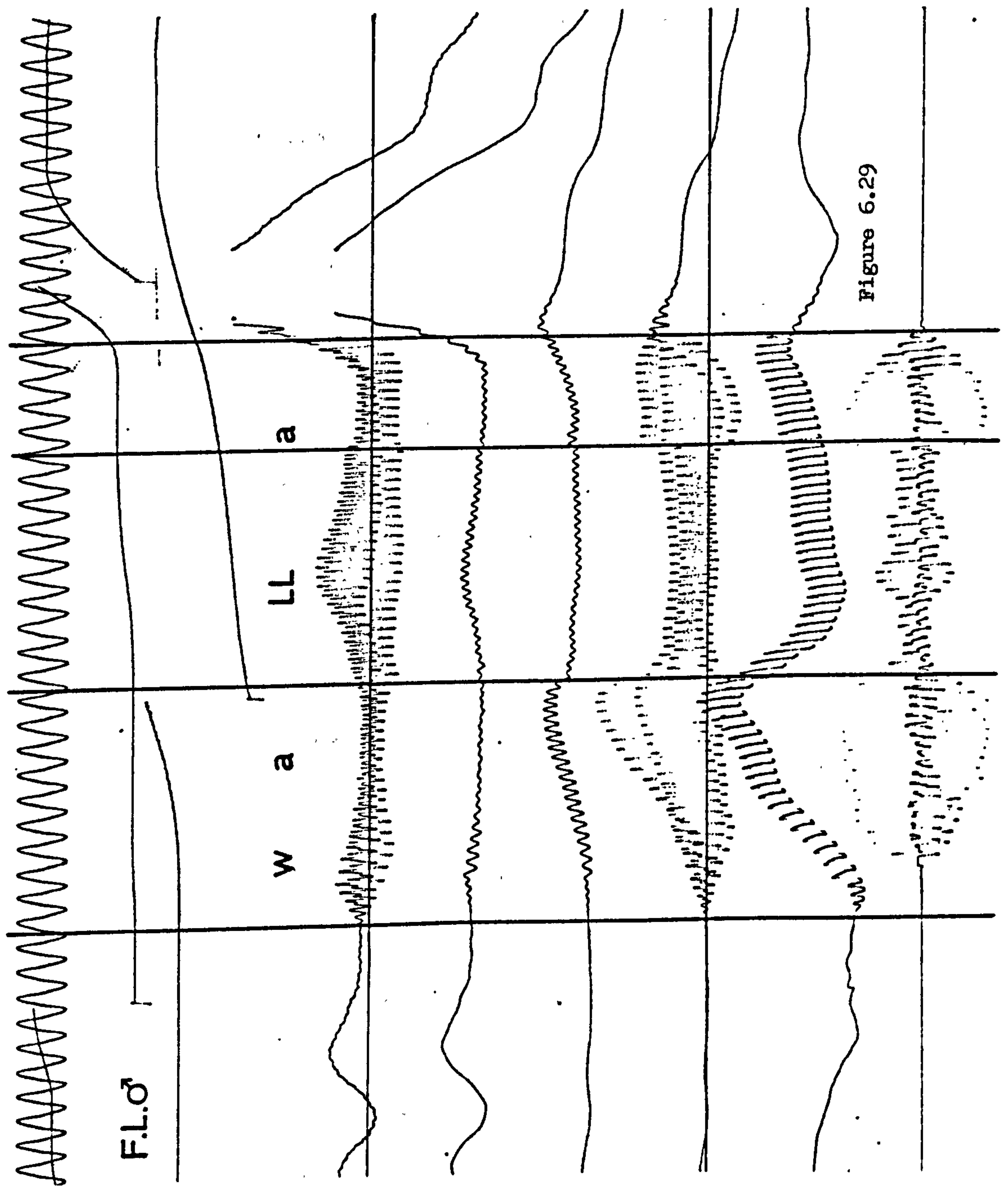
Airflow analysis

In the aerograms made of the pharyngealized and non-pharyngealized words, in general, no major differences exist between the two groups. Both exhibit very similar patterns of airflow waveform. For example, the total duration of /ti:n/, Figure 6.22, and /Ti:n/, Figure 6.23 differ by only 6%. This may be the result of citation form reading, but the individual segmental durations are also similar. At release, there is only a short duration low amplitude burst of aspiration and nasal flow commences at the same point after voicing starts.

In the case of /so:m/, Figure 6.24 and /So:m/, Figure 6.25, the same comments can be made with the soft palate lowering in both at about 3/4 of the duration of the vowel. The duration of complete closure for /s/ and /S/ is the same, as far as one can measure. In the comparison, /dull/, Figure 6.26 and /Dull/, Figure 6.27, however, the voicing for the initial plosive /D/ has almost double the duration of /d/; the durations of the other segments on the other hand, are very similar.

In these sets, the significant variation between the two groups occurs in the LX trace. For the pharyngealized consonant, there is a stronger and more vigorous pull downwards of the larynx, followed by a rapid upward recovery movement which might well indicate an 'overshoot'. In the pair /walla/, Figure 6.28 and /waLLa/, Figure 6.29, the pattern of movement is reversed with a large upward movement occurring during the preceding vowel.



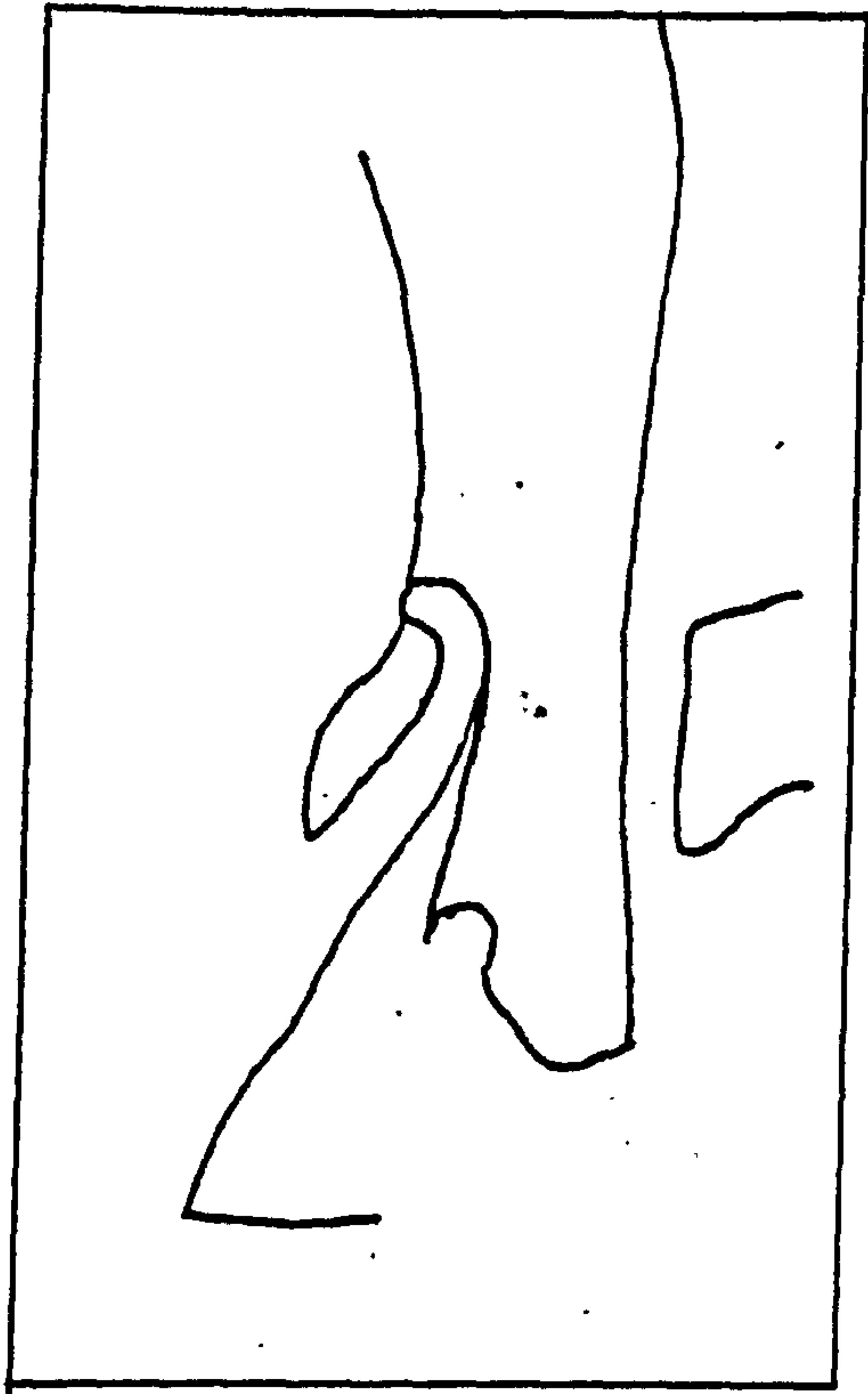


CHAPTER VIIDiscussion and Conclusions

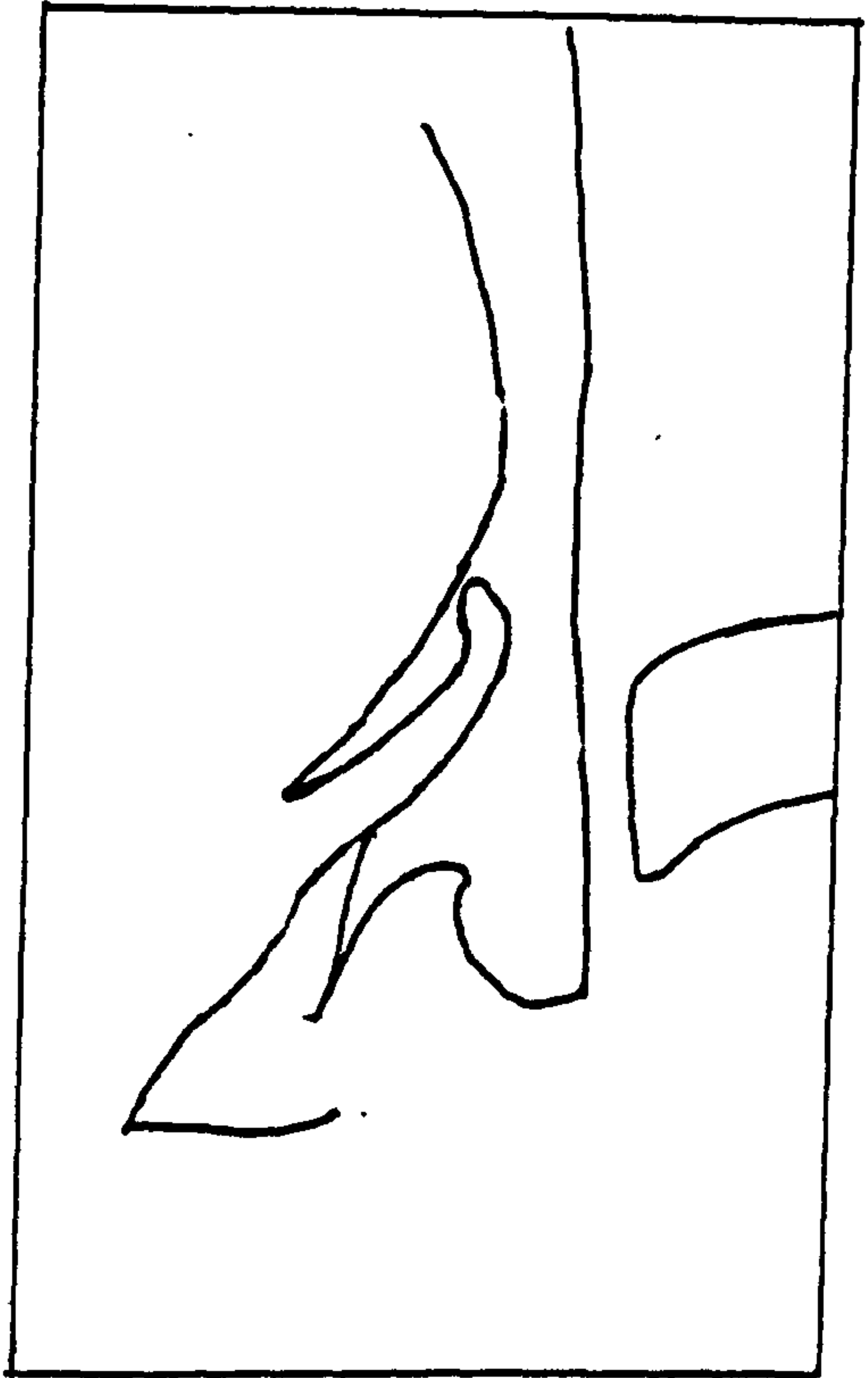
It is pertinent at this stage to examine the articulatory features that characterise the pharyngeal, uvular and the pharyngealized consonants, and see how far they are mutually related and how far they differ. In spite of various studies of these consonants, certain problems remain unsolved, mainly those with regard to the allophones of the pharyngeal /3/. Another controversial issue concerns those consonants that are not represented in the Arabic orthography as pharyngealized, even though in some cases, they behave like 'true' pharyngealized consonants.

It is hoped the results of experimentation of the available data for this thesis will shed light on many aspects of these problems.

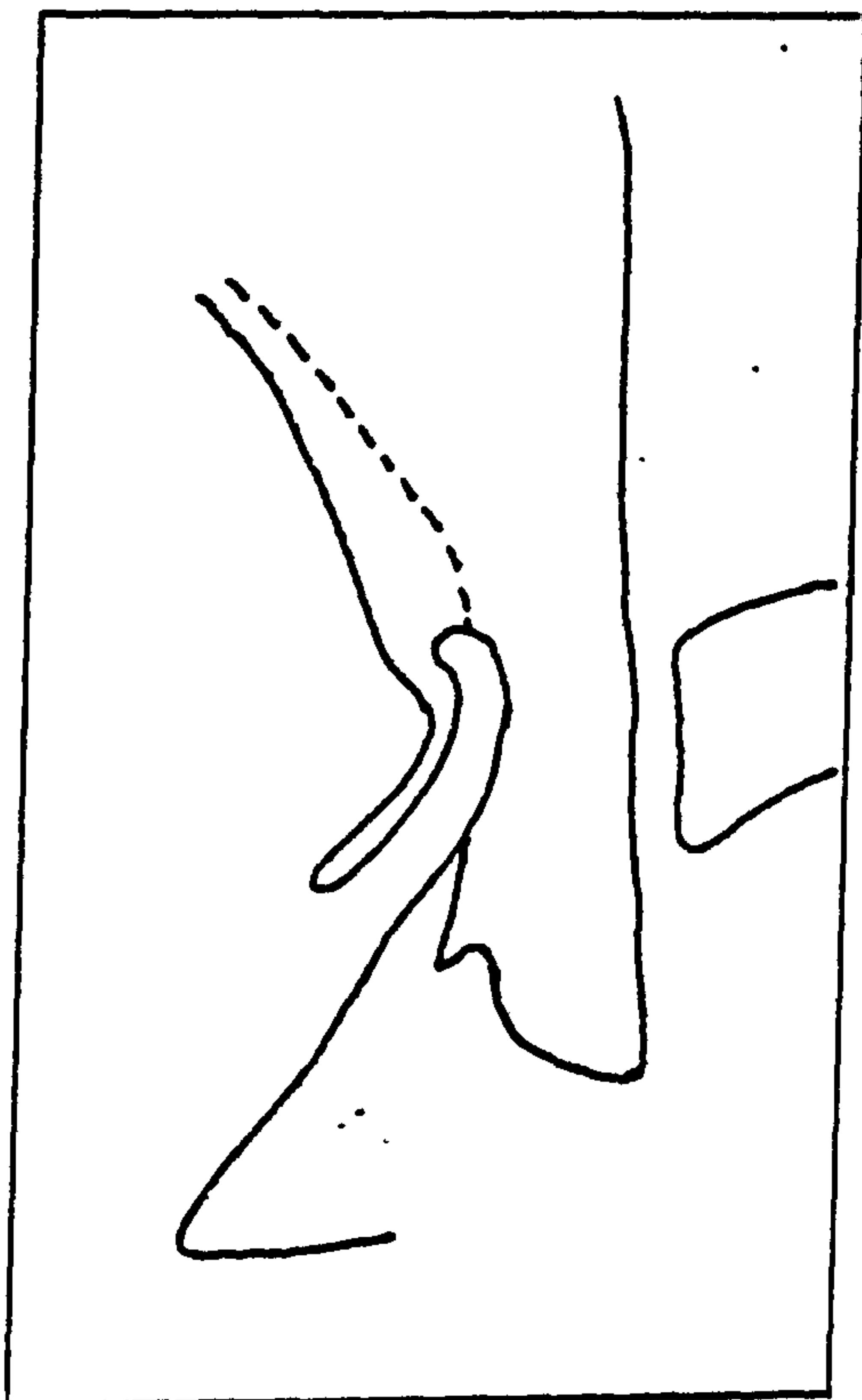
Tracings of the epiglottis (from xeroradiograms - the dotted line represents the other edge of the tongue) shown in Figures 7.1 and 7.2, show the extent of movement of the epiglottis from the 'at rest' position, to the geminated uvular stop, /qq/, the geminated pharyngealized lateral /LL/ and the non-pharyngealized /ll,



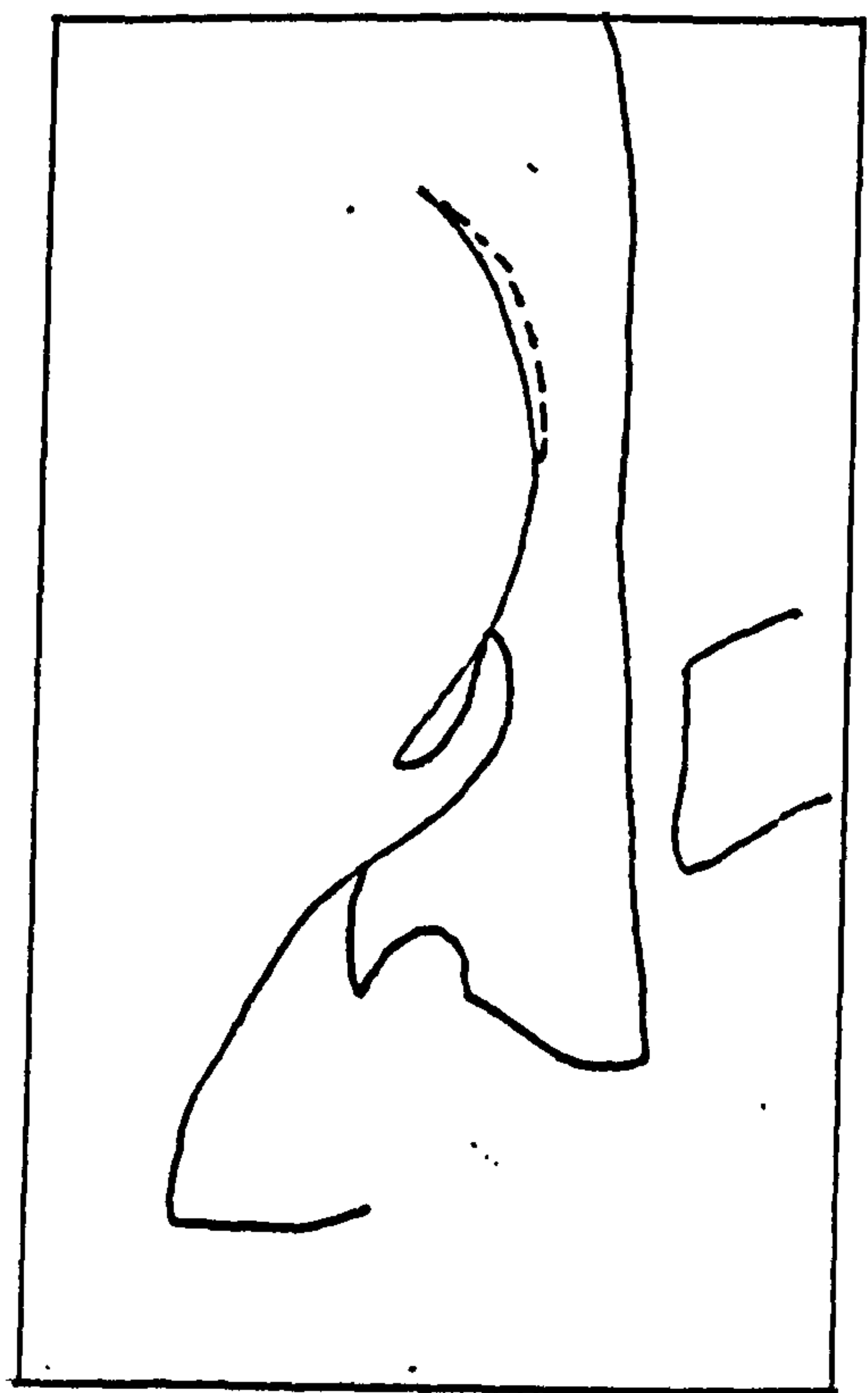
a.



b.

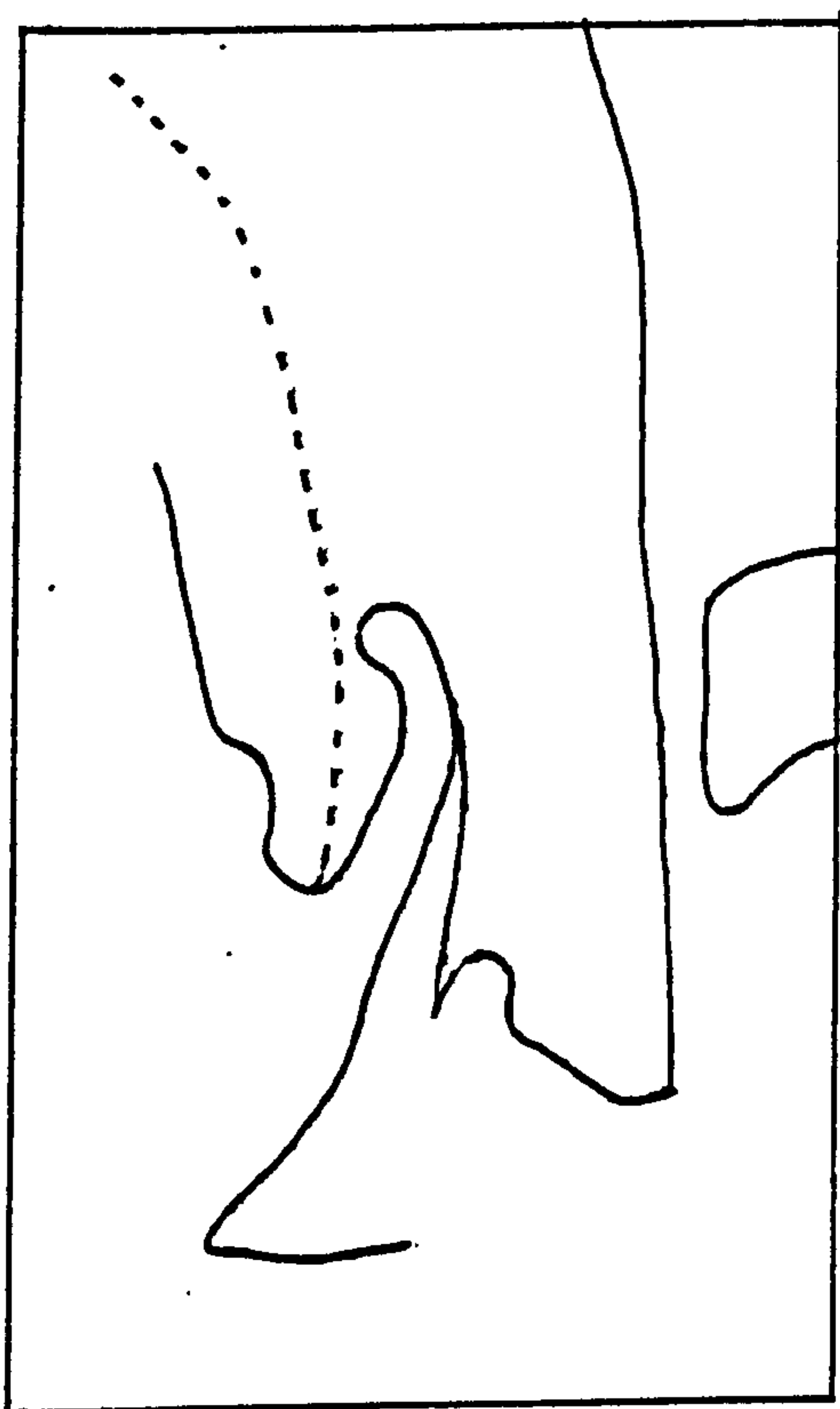


c.

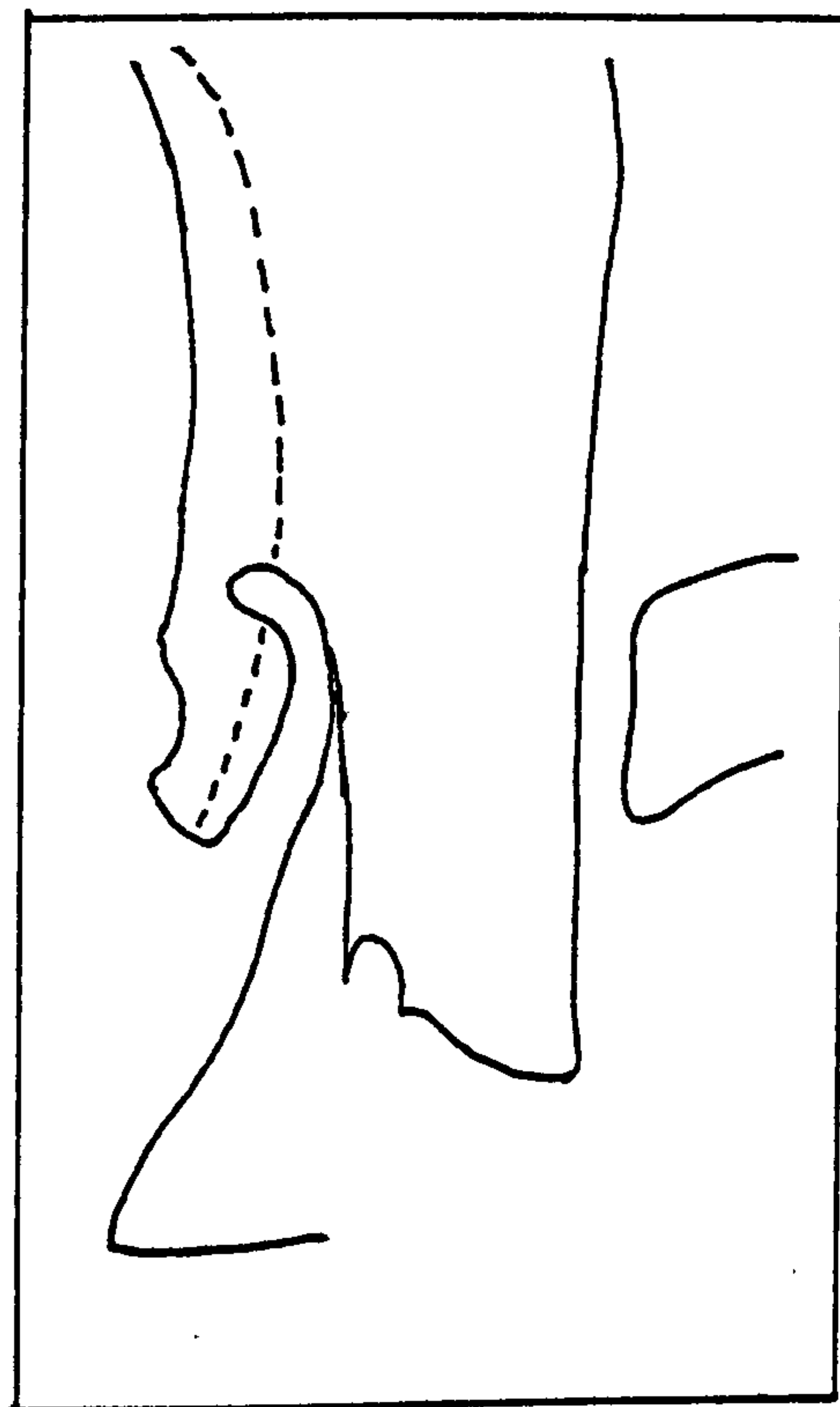


d.

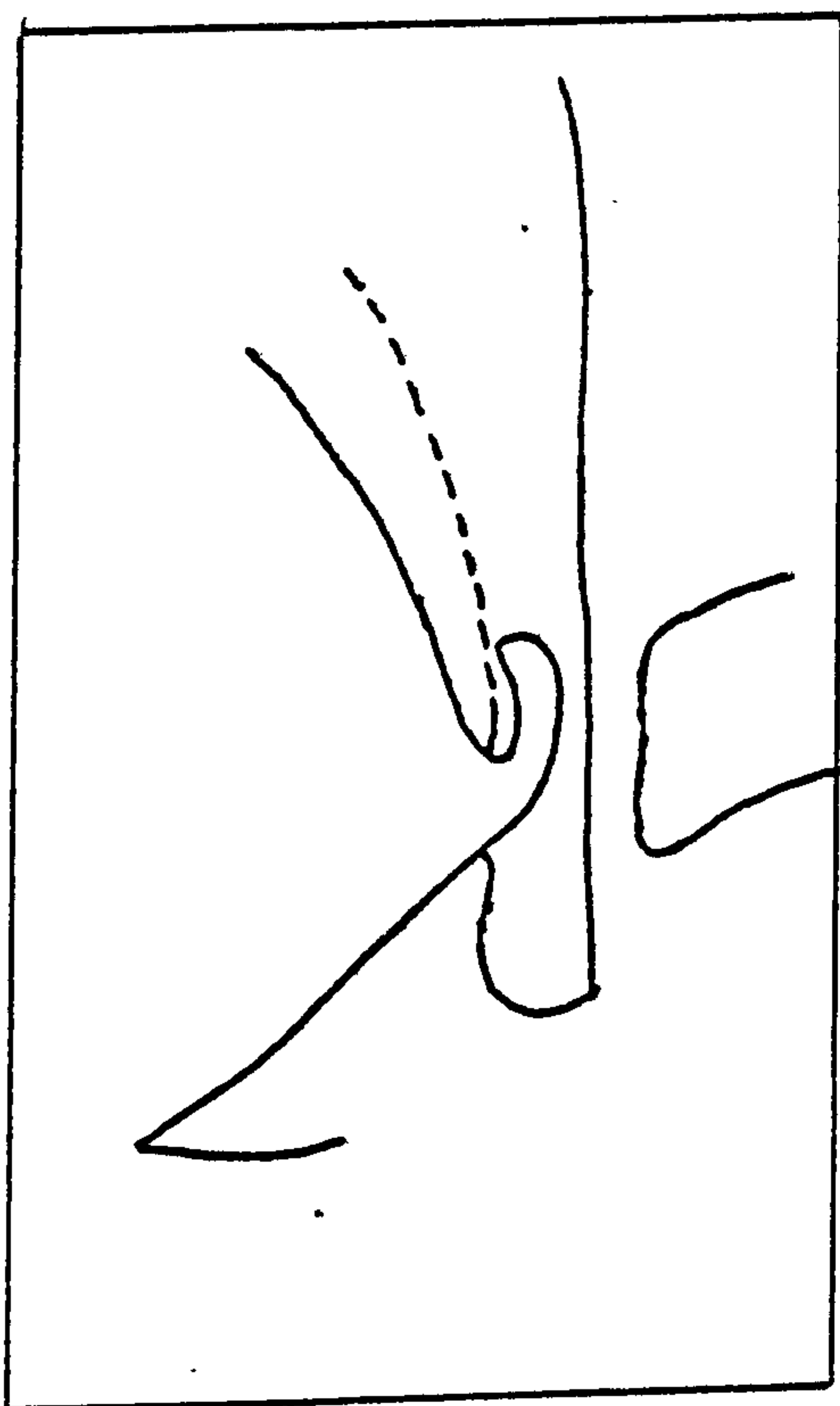
Figure 7.1 Lateral xeroradiographic tracings of the epiglottis



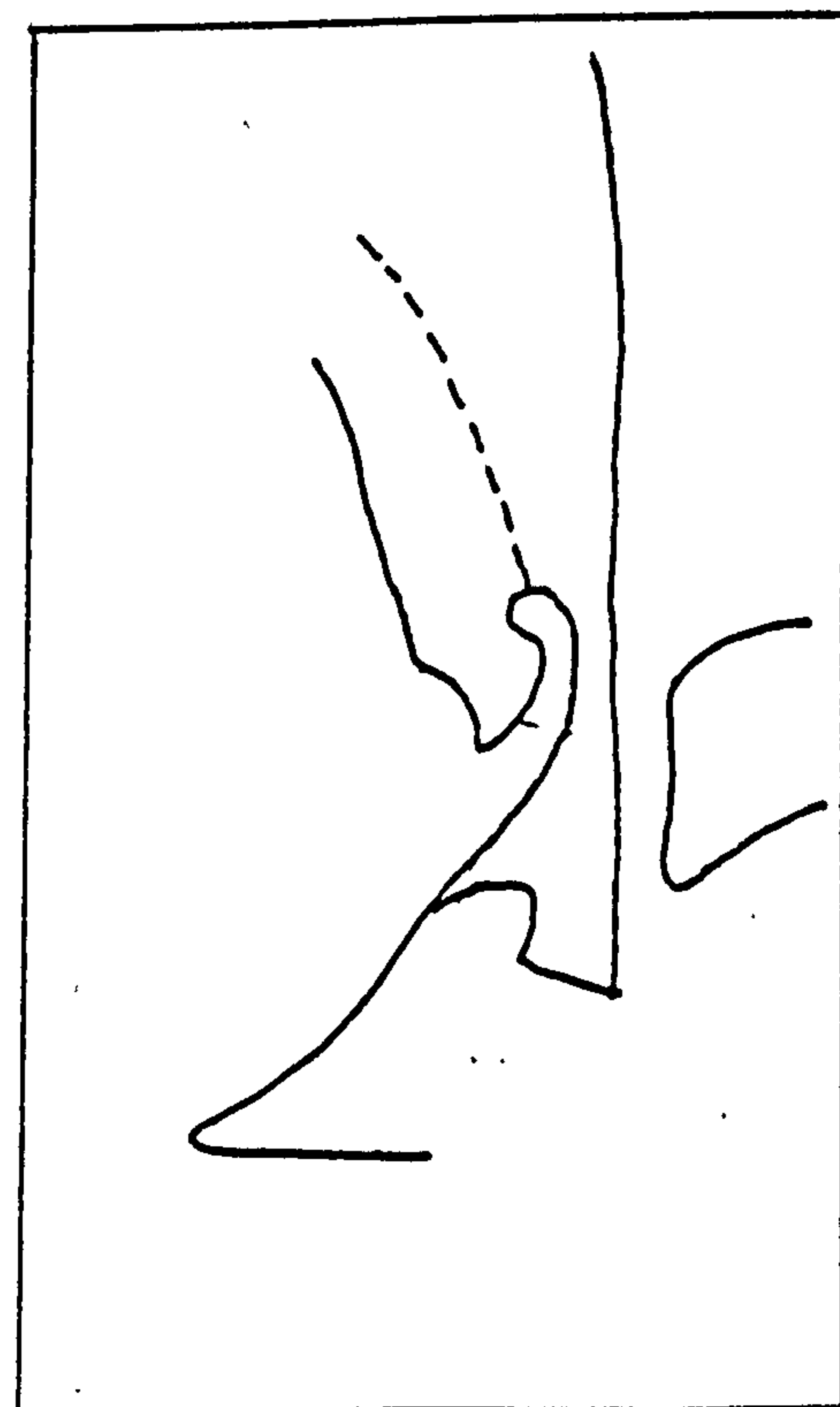
a.



b.



c.



d.

Figure 7.2 Lateral xeroradiographic tracings of the epiglottis

the vowel /i:/ adjacent to both the pharyngealized /T/ and its non-pharyngealized counterpart /t/, and finally, to the pharyngeals /ħ/ and /ʕ/. Figure 7.1.a shows the epiglottis in the 'at rest' position. The root of the tongue is in contact with the epiglottis only at the top edge, though in the endoscopic films, the tip of the epiglottis is usually a little distance away from the root of the tongue. However, this is quite expected because the epiglottis is not retracted towards the back wall of the pharynx; moreover, when the tongue is in the 'at rest' position the epiglottis can lie very close to the tongue root. Figure 7.1.b shows how the epiglottis is retracted towards the back wall of the pharynx in the articulation of /qq/ in /riqqa/. There is a raising of the tongue and larynx, and the impression from endoscopy is of the epiglottis, in resisting the resulting backward pull stretches and uncurls its tip.

A similar action is observed to occur for the epiglottis during the articulation of /LL/ in /WaLLa/, Figure 7.1.d. Here, because the position of the tongue, constriction is not as high as it is for /q/, the epiglottis is not raised and it is, in fact, lowered from the rest position. Its whole length seems to shorten considerably having an almost upright shape, that is, the tip is uncurled almost completely. From the video-endoscopic film record, the epiglottis seems to be resisting the downward and backward movement of the tongue (which would result in a

wider gap between itself and the back wall of the pharynx), and although the larynx is raised, its upward shift is relatively small compared to that of the uvular /q/.

In the non-pharyngealized /ll/ in /Walla/, Figure 7.1.c. the epiglottis takes up a position very similar to that considered to be the 'at rest' position. The tip is curled, but unlike the 'at rest' position, the root of the tongue is some distance away. This shape of epiglottis is, most probably, the same for all the non-pharyngealized consonants and the vowels (it is certainly the case with /i:/ in /ti:n/, Figure 7.2.a). The lower part is slightly upright because the tongue is pulled forward, and because there is a downward movement of the larynx. The forward and upward movement of the tongue, and the downward movement of the larynx both help to bring the epiglottis in the upright position.

In /Ti:n/, Figure 7.2.b, the tip of the epiglottis does not uncurl during the articulation of /i:/ as it does for a pharyngealized consonant even though /i:/ is adjacent to /T/. The root of the tongue is, however, closer to the epiglottis for /i:/ in /Ti:n/ than it is for /i:/ in /ti:n/. Surprisingly, the tip of the epiglottis is curled forwards more for /i:/ adjacent to /T/ than when it is adjacent to /t/.

During the articulation of /ʎ/ in /naʎʎa/, Figure 7.2.c., the epiglottis seems to shorten under the great

muscular tension exerted on its base by the extreme backward movement of the root of the tongue, and also by the upward movement of the larynx. The tip of the epiglottis uncurls and comes very close toward the back wall of the pharynx. During the articulation of /ʒ/ in /maʒʒana/, Figure 7.2.d, pressure exerted by the root of the tongue on the epiglottis is somewhat less than that for /ʁ/, because the tongue root is slightly further away from it, and the epiglottis does not shorten.

Because the retraction of the tongue involves only the root for the pharyngeals, the upper edge of the epiglottis is generally not affected, that is, pressure is not exerted on the upper part of the epiglottis, in contrast to what happens when pharyngealized consonants are produced. The retraction of the tongue extends from the base or root of the tongue to the dorsum, exerting pressure on the whole epiglottis, causing it to uncurl, but the epiglottis resists this push towards the back wall of the pharynx.

Endoscopic observation of the articulation of the pharyngeal /ʒ/ did not show any major variations in the configuration of the pharyngeal cavity among all the subjects. SA's and MB's articulation of the pharyngeal /ʒ/ is auditorily and acoustically similar, but different from that of FL, JS and WL. Nevertheless, the considerable constriction in the pharynx achieved by the retraction of the epiglottis against the back wall of the pharynx and the approx-

imation of the lateral walls of the pharynx at the level of the epiglottis proves to be quite similar for all subjects. The variations that exist in the degree of approximation appear to depend on several factors. It was found, for instance, that prolonging the articulation of /ʒ/ or /ʁ/ in isolation, that is, 'stretching' the sound, produced the maximum constriction in the pharyngeal area. This maximum constriction was also observed to occur for the two pharyngeals regardless of the position of the pharyngeal sound in the word, single or geminated. Undoubtedly, producing these sounds in isolation enhanced their fricative quality - but it seems clear that the articulatory patterns of movement for these pharyngeals are produced in the same way by all the subjects regardless of the auditorily and acoustically different results. It is pertinent to say then, that there are no apparent variations in the type of constriction between the two pharyngeal consonants; both exhibit very similar configurations for all subjects, and any variations that occurred even within one subject cannot be attributed to the position of the segment in the word. Their articulatory manifestations are alike whether the pharyngeal segment is in initial position, e.g., /ʁadd/, /ʒadd/, /ʁilim/, /ʒilim/, medial, e.g., /waʁʁada/, /waʒʒada/ or final, e.g., /sama:ʁ/, /sama:ʒ/.

The variations that do exist can be attributed to many factors. The relatively wide gap that appears during the articulation of, for instance, /ʒ/ in /sama:ʒ/, as said

by FL, can only be explained in terms of 'manner of speech'. That is, FL is heard to say this word in a very over-relaxed manner. However, a slightly wider gap was also observed to occur between the epiglottis and the back wall of the pharynx during the articulation of /ɣ/ in /sama:ɣ/ as said by FL. A very similar gap in the pharynx was also observed during the articulation of the medial /ɣ/ in /raɣa/ by WL. This slightly wider opening for /ɣ/ and /ʒ/ was also observed for the articulation of these sounds by all subjects.

Findings from endoscopic investigation of the pharyngeal consonants regardless of the dialect spoken or whether the subject is male or female share features which can be summed up thus:

- a) A very considerable constriction of the pharyngeal cavity at the level of the epiglottis, an antero-posterior one made by the retraction of the epiglottis towards the back wall of the pharynx - (possibly coupled with a forward movement of the back wall of the pharynx itself). Also, a lateral constriction made by the side walls of the pharynx, which enclose against the epiglottis. Tongue root does not appear. Upper edge of epiglottis uncurls slightly.

- b) No variations of opening or closure in the constriction exist among the subjects studied. All exhibit a very narrow constriction. In some cases, the opening was slightly larger, but this variation did not take a consistent pattern, and did not seem to be related to the position of the segment in the word.
- c) Both sounds show exactly the same articulatory pharyngeal configuration. This was observed for all the subjects.

In some cases, /ʕ/ showed a slightly wider opening, but this was observed in another example of /ħ/.

When these findings are added to those of the radiographic and the acoustic analyses, one can conclude that the assumption (or in some cases, the firmly-held view) that the stop allophone of /ʕ/ in some Arabic Dialects is made by the epiglottis against the back wall of the pharynx, is not accurate.

Spectrographic analysis of the pharyngeal /ʕ/ of the Iraqi subject, (SA), shows that /ʕ/ can be a fricative or a stop, whereas, the examples studied of subjects FL, JS and WL showed that it is either a voiced fricative or approximant. Radiographic investigation for /ʕ/ by FL, JS and WL showed a close approximation of the epiglottis and the back wall of the pharynx, but there is no closure.

Unfortunately, no radiographic evidence is available for SA to compare findings, but reference can be made to MacCurtain's Xeroradiograms (1982), of her Iraqi subject of 'the pharyngeal stop'; where there is no doubt that closure is effected by the epiglottis and the back wall of the pharynx. It seems reasonable then to accept that a good closure is effected at the level of the epiglottis. The endoscopic view of SA shows the epiglottis curling forward leaving some space between itself and the back wall of the pharynx. This part is very dark, however, but one could assume that closure is taking place a little lower down. This assumption is rejected simply because the same configuration occurs for the TA subjects as well, also observed from video-endoscopy. The closure then, is taking place somewhere below the epiglottis, probably at the arytenoids. In which case, Laufer and Condax's 'double closure' can be applied here. Nevertheless, the articulation of the pharyngeal /ʕ/ in Arabic dialects and Hebrew, requires a great constriction in the pharynx by the epiglottis against the back wall and lateral walls of the pharynx. To produce a pharyngeal stop, a closure is probably achieved simultaneously in the larynx. The great epiglottopharyngeal constriction is not the main place of articulation of the pharyngeal stop. In some cases, a greater epiglottopharyngeal constriction was observed during the articulation of /ʕ/ by WL and FL, whose /ʕ/ is either a fricative or an approximant. Also, this pharyngeal configuration is observed during the artic-

ulation of the voiceless pharyngeal fricative /ħ/ in all the subjects.

The voiced pharyngeal, /ʕ/ is invariably described as 'strongly articulated'. Willmore (1905), says " ...⁶ is a strong guttural of the same nature as h, and peculiar to the semitic languages, but is not quite as strongly articulated in Cairene as in some other Arabic dialects". Willmore's impressionistic view is confirmed by later experimental evidence. (Shaheen, (1979), in his acoustic study of Cairene describes the 'voiced pharyngeal' as a semi-vowel. Others consider it as an approximant, (Catford, 1977). This strong articulation, usually characterizes Bedouin speech*.

The assumption made is that size of the oropharynx must be proportional to the degree of 'strength' of the articulation of /ʕ/. That is, the narrower the pharyngeal cavity, the 'stronger' the articulation. However, lateral radiographic tracings of various Arabic dialects seldom support this assumption. Lebanese Arabic is not generally

* It is interesting to note that non-Arab speakers can acquire this pronunciation from native speakers. The author recollects that years ago, when Professor T. F. Mitchell (an Arab linguist) said her surname, which has a voiced pharyngeal fricative /ʕ/, his pronunciation of this sound struck her as that of a Bedouin. Professor Mitchell studied the Bedouin dialect of eastern Libya and this is probably the explanation.

characterized by a 'strong articulation' of /ʒ/, but Delattre's X-ray tracings (cited in Hetzron, 1969), show a very narrow pharyngeal cavity. On the other hand, Al-Ani's X-ray tracings of this consonant show a relatively large pharyngeal cavity. This is probably because his tracings are of the pharyngeals of Baghdad Arabic. Iraqi, especially that of the southern part, as well as most Eastern dialects, are characterised by the 'strong articulation' of /ʒ/. It is possible that during experimentation, the subject is more likely to put more emphasis on the investigated segment, and thus exaggerate its articulation. This may explain the relatively narrow pharyngeal cavity made by drawing the whole tongue backwards in the articulation of /ħ/, and /ʒ/ in /naħħa/ and /maʒʒana/ by WL and of /ba:ħ/ and /ba:ʒ/ by JS. (Xeroradiographic and X-ray evidence in Chapter 4). The pronunciation of /ʒ/ in TA is either an approximant or a fricative.

The question is whether this horizontal dimension coincides with a vertical one, that is, can a low or high level of constriction be the cause of this peculiar articulation of /ʒ/? Catford, (1977), describes /ʒ/ in Egyptian as 'faucal'. That is, made by the faucal pillars, which as Laver (1980:56), describes them, "can constrict the vocal tract in an approximately coronal cross-section at the back of the mouth".

This probably explains Catford's folding, mentioned in Chapter 4, which he says can be visible. The muscles of the faucal pillars are capable of lowering the velum. The palatoglossus raises the tongue if the velum is fixed by the palatal elevators. At the same time, the vertical dimension of the pharynx is narrowed by raising the larynx by the help of the palatopharyngeus. The contraction of the palatoglossus and the palatopharyngeus muscles constricts the faucal pillars (Laver, 1980). These functions of the faucal muscles are requisites for the production of the pharyngeal consonants. This constriction of the faucal pillars is associated with a peculiar type of voice quality described by Bell, (1908:123), cited in Laver, 1980:57). "When the posterior pillars of the soft palate approximate so closely as almost to touch, a very disagreeable reedy quality of voice results". It is possible, then, to relate this place of articulation of /ʕ/ to its 'strong articulation'. Thus, Cairene Arabic is excluded. It is also possible that this 'faucalization' is associated with "lower pharyngeal constriction, glottal tension, and usually a raising of the larynx", (Pike, 1943, cited in Laver, 1980:57). In this case, it is possible that other varieties of Arabic with 'strong' pharyngeal articulation are produced in this manner, especially where lateral radiographic tracings show this lower level of pharyngeal constriction. 'Faucalization', then, can be one of the requisites of the articulation of /ʕ/ in some Arabic dialects. Laver, (1980:58) suggests that "Given that the palato-

pharyngeus is connected to the thyroid cartilage, it is not surprising that its contraction should be associated with a disturbance of the fine mode of vibration of the vocal folds, and with constriction of the lower pharynx and upper larynx".

The constriction in the pharynx is not restricted to being made by the rearward movement of the body of the tongue. Sphincteric constriction can occur in certain sounds and certainly in the articulation of the pharyngeal sounds. Ladefoged, (1974), and Mackay, (1976) found that size and width of pharyngeal cavity varies independently of tongue constriction or height.

All the extant radiographic data consists of lateral views in which this type of contraction cannot be expected to be seen. Axial views (through the top of the head) are sometimes very helpful, though difficult to interpret, but they are difficult to make (and give unnatural speech) as they require the head fully forward with the chin on the chest.

Fletcher (1957), in his study of the forward movements of the back wall of the pharynx during phonation in normally pitched voices of ten subjects found that movements during phonation are considerably less extensive than movements during swallowing. The posterior pharyngeal wall is divided by him into superior and inferior parts with the

line separating these two parts at the level of the lower half of the atlas. This line was found applicable for both phonation and swallowing. He also found that the superior movement occurs only after the soft palate makes contact with the posterior pharyngeal wall. "The inferior part of the posterior pharyngeal wall remains in a relatively constant anteroposterior position throughout the sequences of phonation". Even though Fletcher's inferior part accounts for the level of the axis (approximately the level of C1), where he observed "a small ridge" on the posterior pharyngeal wall in only one subject, he did not observe any significant movement of the back wall of the pharynx. Also, Hagerty, et. al., (1958), found that "In general, except when Passavant's phenomenon occurs as a function necessary to closure, it is doubtful whether the actual extent of forward excursion of the posterior pharyngeal wall is clinically significant in the production of speech sounds". Also, Hagerty and Hill, (1960), in their study of pharyngeal wall and palatal movement in post-operative cleft-palates and normal palates found that "For both clefts and normals, the actual amount of forward excursion of the posterior pharyngeal wall is very small and its contribution to speech is probably insignificant". However, they did observe a tendency for more forward pharyngeal wall movement in the postoperative group than in the normals.

The above investigators all seem to be concerned with movements of the back wall of the pharynx at a high level, that is, movements of the back wall of the pharynx at the nasopharynx level, though Fletcher's experiment also included a lower place about the level of C1 in the oropharynx.

Looking at Traill's film (1978), forward movements of the back wall of the pharynx are extensive and are associated with side wall movement of the pharynx and considerable trilling of the epiglottis. All these movements occur during phonation, which possibly explains why these movements are exaggerated in relation to speech.

It is difficult to determine if the movement of the back wall of the pharynx is posteroanterior or vertical, because the view is vertically down the pharynx. The extensive rearward movement of the epiglottis makes it difficult to be sure of the direction of movement of the back wall of the pharynx. The movement may be made upwards and inwards, though radiographic evidence fails to show forward movement of the back wall of the pharynx. To add to the problem, no consistent patterning was evident.

There would seem to be three main causes for this apparent movement of the back wall of the pharynx:

- 1) a raising and lowering of the larynx, 2) an inward movement of the side walls and 3) a general interaction of the muscles on that region of the pharynx.

Measurements of the xeroradiograms, however, show no forward movement of the back wall of the pharynx, even though these measurements were taken at different levels in the pharynx, and one can only conclude that constriction of the pharynx is mainly achieved by the projection backwards and in certain cases, upwards of the tongue. This statement, however, gives insufficient weight to the role of the lateral walls of the pharynx. Lateral views from radiographic experiments fail to show this, though axial views may show good cross-sectional areas of the pharynx. This is, however, better achieved by the endoscopic technique which clearly shows how highly significant the lateral wall movement can be in certain sounds, especially the voiceless uvular stop /q/, (which showed extensive inward movement of the lateral walls of the pharynx, particularly for the Iraqi subject (SA)X. It was, however, not easy to determine exactly the actual place of this movement. It may well be that different sounds have different places of lateral wall movement along the vertical axis of the pharynx.

It was a problem to determine the significance of the lateral wall movement in different sounds apart from the uvular stop /q/. This side wall movement is very rapid. It starts a little after the rearward movement of the tongue and is relaxed before the tongue moves away from its rearward position. Lateral wall movement occurs for the uvular fricatives /X/ and /g/, but to a lesser extent than for the uvular stop /q/. It occurs for the pharyngeals /ħ/ and /ʕ/,

though manifested quite differently and most probably of a different level to the uvulars. The constriction for the pharyngeals as seen in the photographs in Chapter 4 is considerable, and in most cases, only a very narrow gap is left between the back wall of the pharynx and the epiglottis. To achieve such a constriction, it is necessary to draw the whole pharynx together anteroposteriorly and laterally at the level of the epiglottis. Lateral wall movement for the pharyngealized sounds and the uvular fricatives, then very likely takes place just above the level of the epiglottis, but that for the uvular stop /q/ appears to occur high up in the pharynx and with such an extensive and rapid movement that makes it unique among these sounds. Hardcastle, (1976:125), states that " ... rapid fluctuations in the lateral width of the pharynx probably do not occur during speech production". The reason behind Hardcastle's reluctance to accept any rapid movement in the lateral walls is based on anatomical factors. Because of the size and shape of the constriction muscles, they are thought capable only of slow movements.

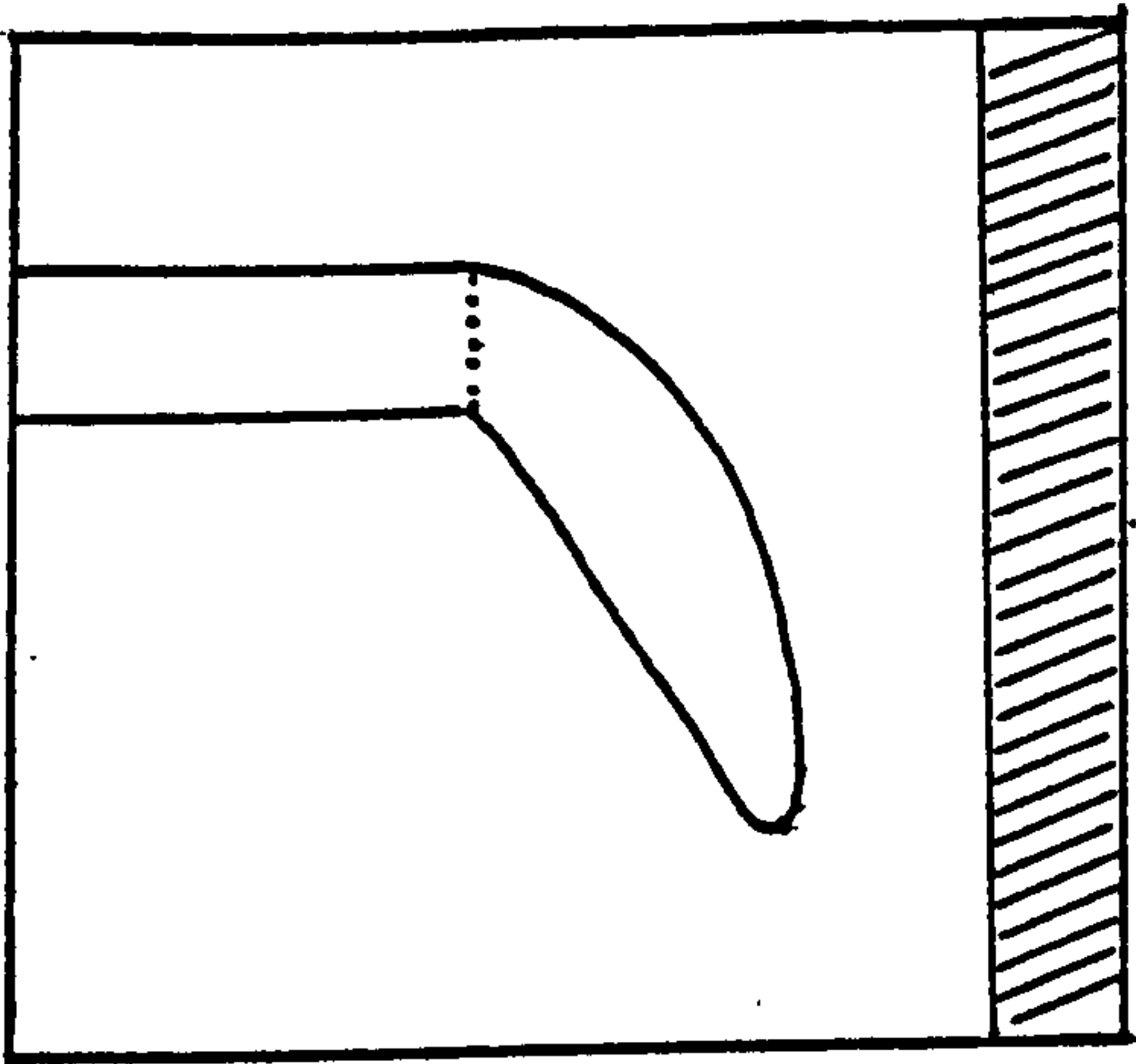
Whether this lateral wall movement is achieved by a contraction of the constrictor muscles or other muscle groups and whether the size and shape of these constrictor muscles may or may not be capable of such constriction, the fact remains that this constriction is considerable, fast and takes place bi-laterally.

One is then justified in saying that the diameter of the pharynx is changed anteroposteriorly and laterally. These two factors may or may not occur together in various degrees and at different levels. It was not unexpected then, to find that the lateral movement of the pharynx in /q/ occurs in a superior position; the constriction of the pharynx for /q/ not only occurs as a closure with the dorsum of the tongue against the underside of the soft palate, but because of this upward movement, the pharyngeal cavity between the tongue and the back wall of the pharynx is narrowed. This, however, cannot be applied to the uvular fricatives /x/ and /g/, though they have a high place of constriction similar to /q/.

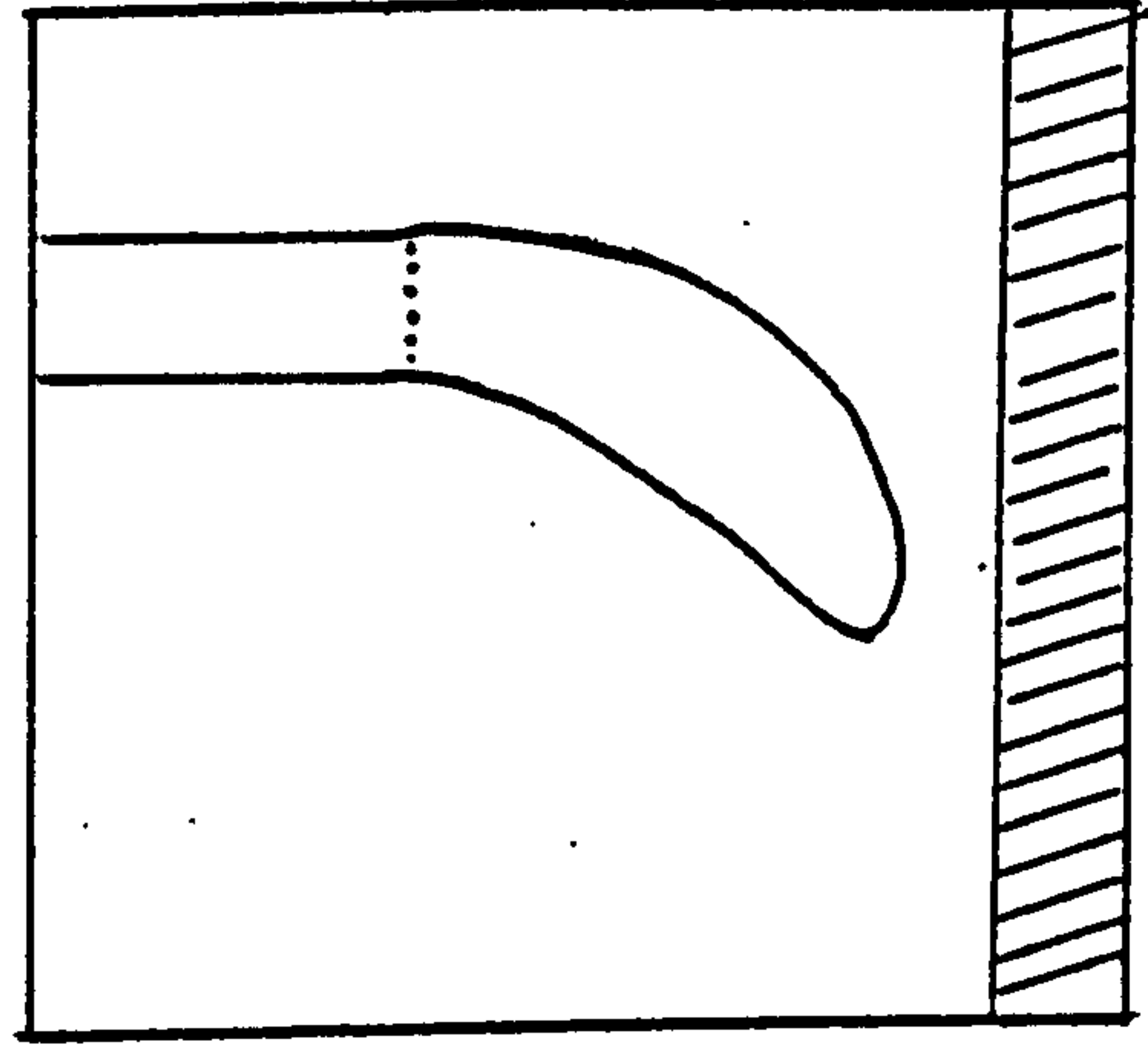
It is convenient to divide the patterns of movement of the soft palate that are associated with the articulation of pharyngeal segments into six types. The two extreme positions of the soft palate, that is, of the 'at rest' position and closure are described by Anthony, (1980:421), as such "The palate at rest is seen to slope downwards and backwards from the posterior margin of the hard palate at an angle of about 40 degrees, and closure consists of a pulling backwards, and upwards, bending the soft palate into a near-horizontal part and a vertical part, which is brought in close to the back wall of the pharynx. If the closure is a firm one, then the upper part against the back wall will be squeezed into a 'knuckle', but however firm or tight the closure is, the vertical part will not necessarily be

against the back wall". Within these two positions, (T1 and T6 of Figure 7.3), four other types are described in relation to the pharyngeal sounds /ħ/ and /ʕ/ and the adjacent vowels. One can consider whether the voiced/voiceless distinction with regard to pharyngeals affects the position of the soft palate.

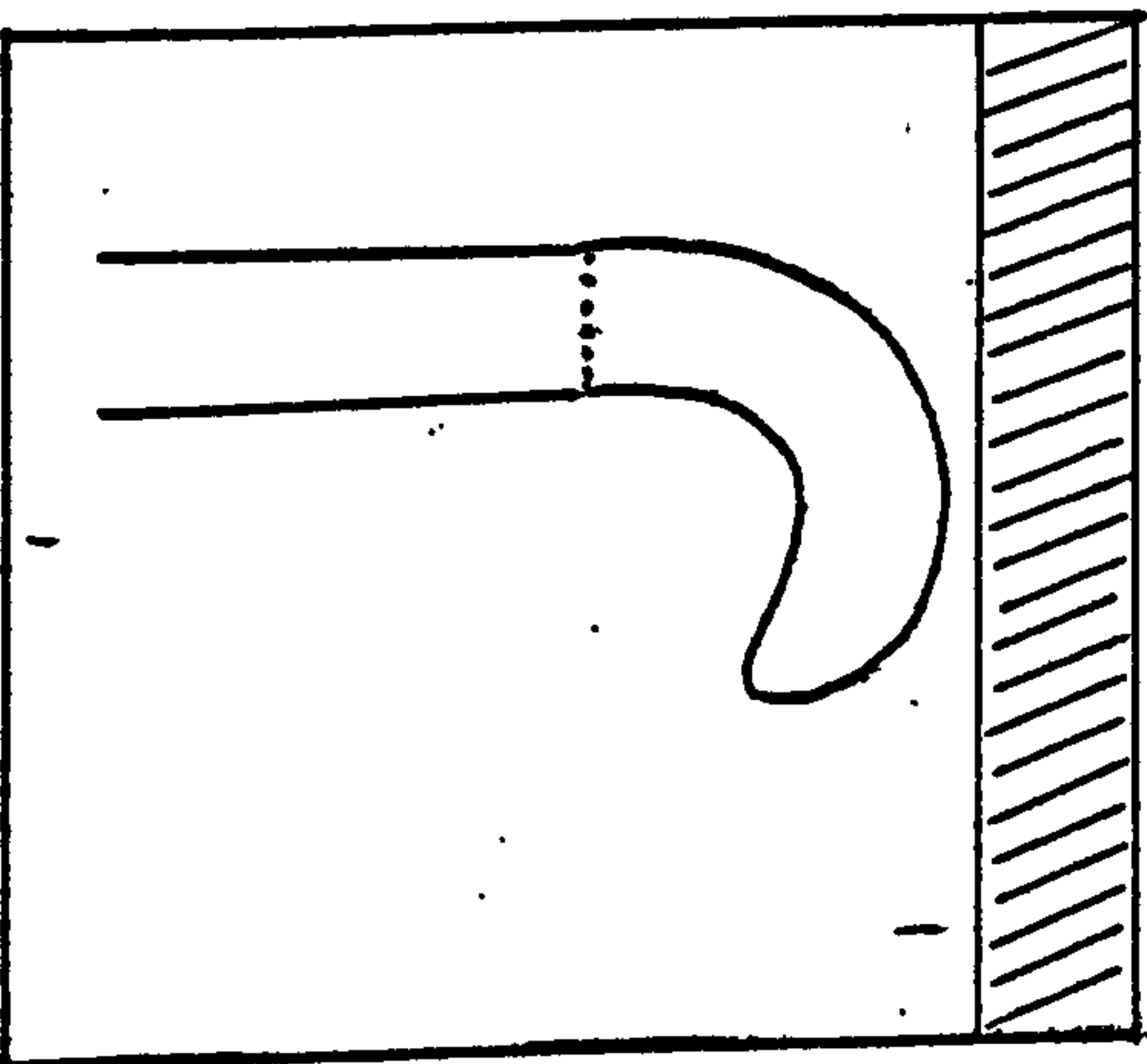
Though nasalization with regard to pharyngeals is perhaps not perceived as such; xeroradiographic, video-fluorographic and airflow investigation show that in the case of subject WL, soft palate lowering occurred in the case of the voiced pharyngeal /ʕ/ in /maʕʕana/. The soft palate is raised (T4) for /ħ/ in /naħħa/. The presence and absence of this feature in the two examples may be due to the presence or absence of the final denti-alveolar nasal /n/. Airflow records of words with the pharyngeals /ħ/ and /ʕ/ of the same subject exhibited a maximum nasal airflow for /ħ/ only when this segment occurred in a word which contained a nasal - and nasal airflow only when /ħ/ is in an initial or final position in the word. Other examples do not show nasal airflow unlike those of subject (FL), whose records exhibit various patterns of nasal airflow regardless of whether there is a nasal sound in the word or not. This coincides with soft palate lowering for these sounds. Less nasal airflow occurs for the voiced pharyngeal /ʕ/ than for the voiceless one /ħ/.



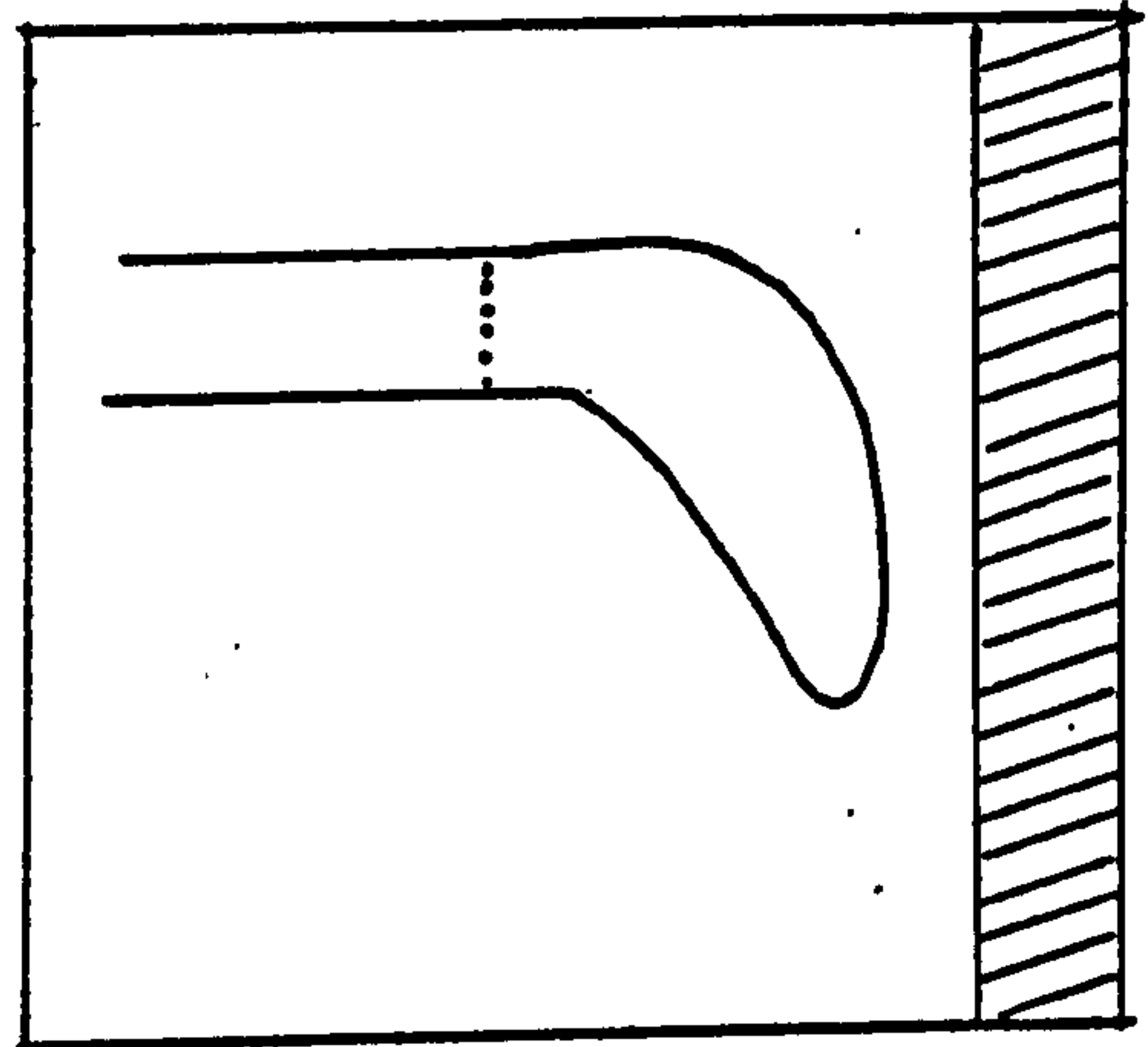
T1



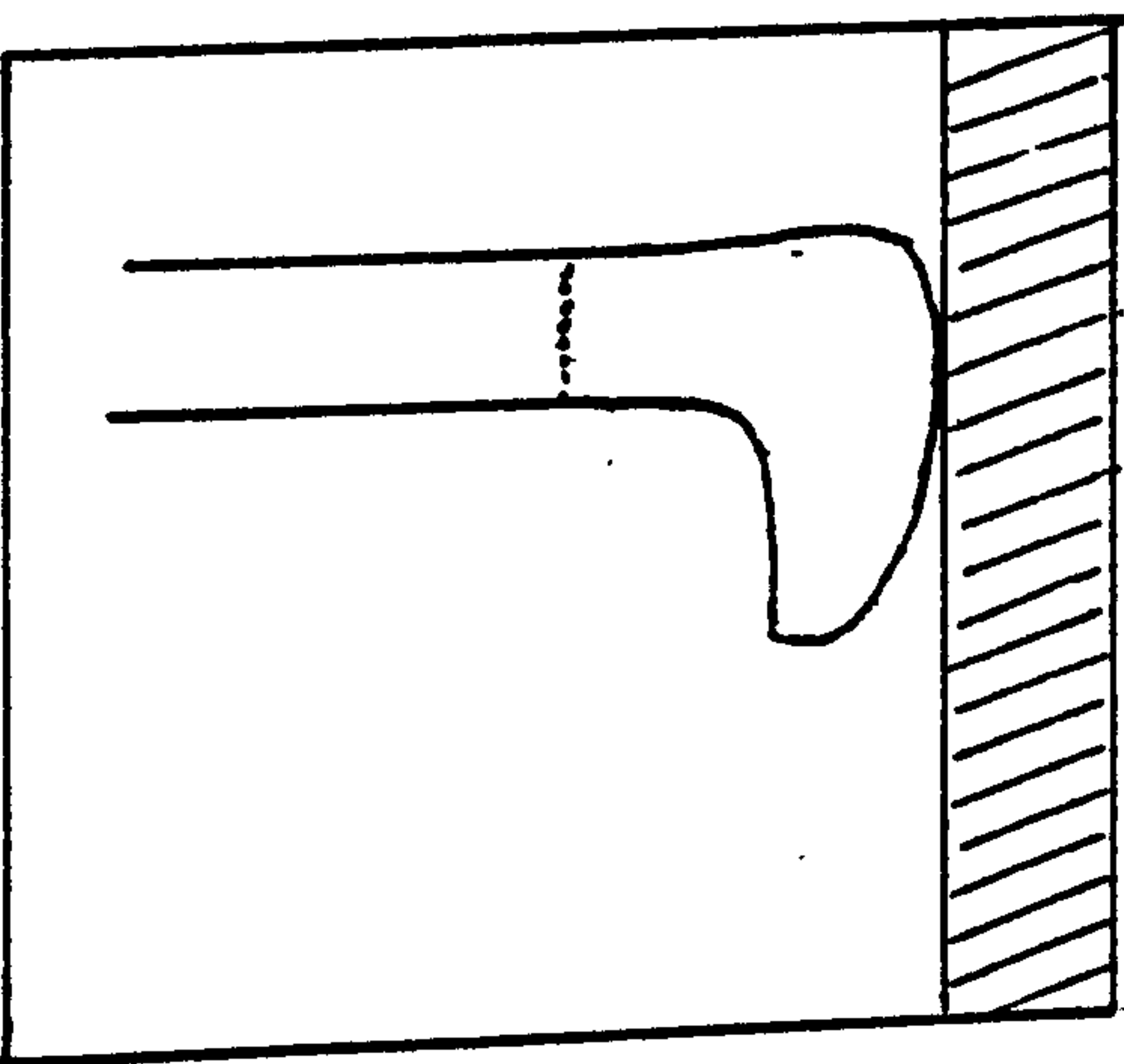
T2



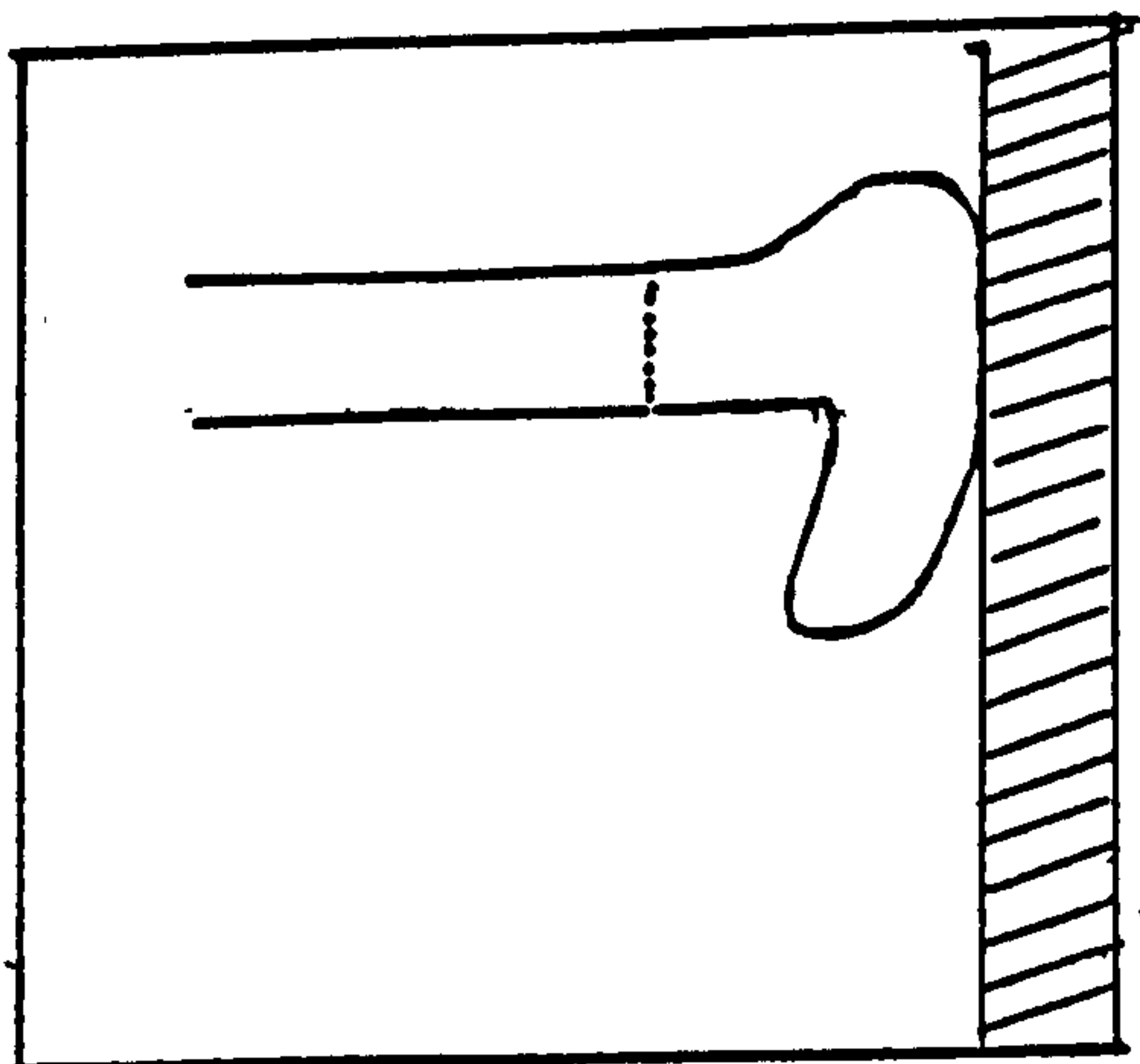
T3



T4



T5



T6

Figure 7.3 Types of soft palate position

In the case of the other sounds, the soft palate is always raised and in contact with the back wall of the pharynx. During the articulation of the adjacent vowels, the soft palate is seen to rise, except in the case of the word /maʒʒana/, as said by FL, where the soft palate position is of a similar type to that for the articulation of the preceding /ʒʒ/. Soft palate seems to have a T6 type of firm closure mostly during the articulation of /T/, even in the word /ʁe:T/ as said by FL.

The maximum airflow rate, oral or nasal occurs for the segment /ʁ/. This may be due to the fact that it is made lower down in the pharynx besides being voiceless. Joiner (1968, cited in Beckett and Hallett, 1971), using the vowel /a/, found that airflow is reduced as a consequence of a high level constriction in the vocal tract. In the case of subject (FL), this high airflow rate always appeared in the nasal waveform, whereas, in subject (WL), it appeared in the oral waveform, except when there is a nasal sound in the word, as in /naʁna/. In general, it was found, from xeroradiographic and videofluorographic experiments, that the soft palate is lower for the voiced pharyngeal /ʒ/ than for the voiceless one /ʁ/. Type 2, Figure 7.3.b is similar to the 'at rest' position, though the soft palate is not as lowered. Instead, it curves down smoothly away from the back wall of the pharynx; as a result

the velopharyngeal orifice is of maximum size. The characteristic feature of Type 3, Figure 7.3. T3 is the curve forwards of the tip of the soft palate. The soft palate is either a) raised and almost in horizontal extension to the hard palate with an opening to the nasopharynx or b) slightly lowered with almost a contact at a lower level of the nasopharynx, while the tip is curved forwards. The curved tip may not touch the tongue. This Type 3 characterises the articulation of the pharyngeals /ɣ/ and /ʒ/, when they are in a medial position in, for instance, /raɣa/, /raʒa/ and /naɣa/ with /raɣa/ and /naɣa/ having a wider nasopharynx gap. The point of near contact occurs for /ʒ/ at a lower level, and the soft palate slopes in a curve downwards and curling the tip forwards. It might be expected that /ɣ/ or /ʒ/ single or geminated in a medial position in an utterance would be of Type 3, but the exception to the rule is the example of /ʒ/ in /maʒʒana/, where the soft palate position is of Type 1. This may be due to the presence of two nasal sounds in the utterance.

Type 4 is seen for /ɣ/ or /ʒ/ in initial and final position with or without a nasal segment in the utterance. The characterization of the soft palate into types is mostly done in relation to shape of soft palate - because even when variations in the nasopharyngeal cavity occur within one type, the shape of the soft palate hardly alters.

Type 2 then, describes the soft palate in a horizontal level with the hard palate, that is, raised upwards slightly with degrees of opening in the nasopharynx being closer for /ɰ/ in /ɰe:T/ and wider for /ʒ/ in /ʒilim/, and /sama:ʒ/.

During the articulation of the vowels adjacent to the pharyngeals /ɰ/ and /ʒ/ the soft palate is of Type 5, irrespective of whether they are front or back, open or closed. They all have the soft palate as Type 5, that is, the soft palate raised upwards and backwards against the back wall of the pharynx, but not having a firm contact with it. In certain cases, the soft palate is not of Type 5, but of Type 4. The vowel /a/, preceded by the pharyngeal /ʒ/ is of Type 2. Evidently, the presence of two nasals in /maʒʒana/ and a pharyngeal as well as an open vowel all help to lower the soft palate down in Type 2 manner. This is also observed for /ʒ/ in one example of /sama:ʒ/. In all other examples of /a/, in utterances with pharyngeals, it is in general of Type 5, though variations are found to occur.

In general, this classification of soft palate configuration into types is applicable to the pharyngeal consonants and the adjacent vowels. The variations that occur can only be explained in terms of mechanical factors which were mentioned in Chapter 3.5. Because of absence of

sound during slow motion or frame by frame display, one cannot ensure that the frame chosen in certain cases for a certain sound coincides exactly with a similar frame for a similar sound. In other words, the articulation of a particular sound can be seen to take a different route through different stages before the articulators reach the target position. Although the articulators may not reach the target position for a particular segment, and before they reach it, they take a position of an adjacent vowel though not quite so. That is, the articulators do not actually achieve the position of the vowel but both segments seem to co-articulate, that is, neither reaches its own target position, but goes towards the position of the other segment. This is more evident in some cases than in others.

Experimental studies on the Arabic dialects were mainly carried out on the speech of men. Very few studies were made by women or on women's speech. It is pertinent, here, to refer to a variation in the articulation of the pharyngealized consonants in relation to the non-pharyngealized ones in men's and women's speech. This variation is heard in some dialects more than in others.

Mitchell (1963), refers to this feature as also does Lehn, (1963), who observed that the features that characterize the 'emphatic' consonants are generally less

prominent in women than in men. Harrell, (1957:81), states that "the general attitude seems to be that if one's normal pronunciation of a morpheme is emphatic, the non-emphatic form seems affected and effeminate". He cites a few examples to support this conclusion, where his subjects' reaction showed that they were aware of this distinction. Gaber, (1972), also observed this variation in Cairo Arabic with regard to the domain of 'emphasis', where he found it to be less extensive in women's speech than in men's.

This feature is quite obvious in Cairene Arabic where men's pharyngealized sounds can be said to stand out more than women's whose articulation of these sounds exhibits only slight variation to the non-pharyngealized ones or none at all. This difference is thought to correlate closely with the socio-economic standard. The less pharyngealization is produced, the higher the socio-economic status of these women. In certain cases, one hardly detects any pharyngealization at all, and only the context would reveal the presence of a pharyngealized sound. In Tunisian Arabic, Maamouri, (1967:40-41), found that "Women and children, in general, and town dwellers in particular are less inclined to give the words containing emphasis the full phonetic quality of this linguistic phenomenon. This does not mean that these categories of people cannot pronounce emphasis or automatically replace

it in their speech by the corresponding plain forms. It proves, however, that like for most other features of the language, there are phonetically varying degrees of emphasis".

Kahn (1975), conducted two experiments in an attempt to categorise the pronunciation of Arabic 'emphatics', using acoustic parameters to compare differences based on sex, and regional origin. Her spectrographic study was based in the first experiment on the speech of two male and two female natives of Cairo. She compared her results to Fant 's (1966), formant values where 'emphatic' vowel was compared to a Swedish vowel whose formant values most resemble it and the 'non-emphatic' formant values were compared to another similar Swedish vowel. This comparison was conducted in order to find out if men and women's articulation of 'emphatics' is anatomically predictable. She found that the difference between the 'emphatic' vowels of men and women, as reflected by F1 and F2 values are significantly higher than Fant's formant values for the corresponding vowels. F2 values are proportionately much more lowered for men in 'emphatic' vowels as opposed to 'non-emphatic' vowels, and the difference between them is far greater than would be anatomically predicted by Fant and in an opposite direction. Her second study was based on samples of speech from male and female native speakers of Arabic representing Egyptian, Palestinian,

Lebanese with a majority of Kuwaiti and Saudi Arabian. The other group consisted of American male and female students of Arabic taught by male Arab teacher. Her spectrographic analysis indicated that Arab women show significant differences in acoustic cues for emphasis to Arab men, which are in the completely opposite direction to the difference expected from their anatomical differences, whereas, the difference between American male and female speakers is less than half. She also found that the overall formant values for Arab women are higher than for American women. The results of the two experiments indicate that the variation in vowel formants is not solely physiologically based.

Ahmed (1979), studied these variations in Cairene Arabic in some detail. Her articulatory and acoustic study was restricted to the primary 'emphatics' S, Z, D and T, because they "provide the most salient differences in pronunciation between men and women". She found that "women's pronunciation, in general, is less emphatic than men's. In the women's case, we notice that the lips are slightly pursed, but no blowing out of the cheeks is observed. The tension of the articulatory muscles is relatively little. The tongue is less flat in the mouth than in the men's case". She also found, in relation to emphatic focal points, that "In women's speech, an initial or medial focal point is more palpable than a final focal point.

In men's speech, an initial, medial or final focal point has the same strength and clarity. In general, in women's speech, when the focal point of emphasis is initial in a word, emphasis pervades the first syllable at which it occurs and becomes less marked in the following syllable".

She also found that in women's speech, there is no clear-cut difference between the duration of the 'emphatic/non-emphatic' segments, while in men's speech, differences of values were obtained and showed that " In general, the emphatic contoid and vocoid segments are longer in duration than the non-emphatic contoid and vocoid segments".

She also found that "F2 in the emphatic items is more extreme in the men's case". And that the values of F3 and F4 are lower in frequency than those of women in the 'emphatic items'. She speculates that this lowering of F3 and F4 in men's pronunciation may be due to the degree of lip rounding or protrusion of which more exists in men's pronunciation.

The difference between the speech of men and women may be due to anatomical and physiological differences which have articulatory implications. Catford (1968), for instance, states that "it is well established that more men than women can roll up the edges of the tongue. This

implies the absence of certain articulatory possibilities in many women and some men. Again, the length and freedom of movement of the tongue varies from one individual to another ". It appears that 'sex typed' variation related to the articulation of the pharyngealized consonants is more present in Egyptian Arabic and in particular, Cairene Arabic, where there is a tendency among men to pharyngealize even those consonants which are recognized as non-pharyngealized*. On the other hand, women tend to go the other extreme and produce the pharyngealized consonants as non-pharyngealized.

The difference perceived in the production of the pharyngealized consonants in men and women's speech seems to be neutralized going east and west of Egypt, so that one could consider the Cairene dialect as representing the maximum difference between the speech of men and women.

The author is inclined to agree with Maamouri, (1967), with regard to this feature that there are varying degrees of 'emphasis' and women and children are more inclined to produce these consonants as less pharyngealized, though they are quite capable of producing them. Undoubtedly, women's speech, in general, is different in some respects from men's speech, and a variation in the production of, for instance, the uvular fricatives /X/

* An example can be drawn from an early song by a well-known Egyptian singer, Mohamed Abdel Wahhab, who pronounces the word /tara/ 'maybe' as [T̤aR̤a] .

and /g/ can be perceived particularly in Cairene women. Their articulation of these consonants is frontal and almost like velars. Also, their vowels are generally more front and close than men's. In TA, for instance, this can be manifested according to education, that is, where within a family there is a member or more than one who is educated, in which case their speech will be influenced by the Classical Arabic. However, in the normal social structure in Libya, there are more women who are illiterate than men. Even among the illiterate men, there are some whose speech has lexical items from Classical Arabic. This is due to the fact that they have more opportunity to mix with other people, for instance, listening to speeches in mosques - whereas, women spend most of their time at home or mixing with other women mostly of the same social background. In some cases, these women may acquire words from Classical Arabic from their children or the media, but there is little doubt these men and children tend to use the type of dialect which these women speak; this might be considered a type of diglossia, which is quite common in this community.

It was found that variations in men and women's speech do exist, especially with reference to pharyngealized consonants. But if this phenomenon is studied within men's speech, no obvious variations are perceived cross-dialectally or in the same dialect. However, experimental evi-

dence, especially radiographic shows that some male speakers of the same dialect exhibit an overall narrower constriction in the pharynx than others. An example of this is given by the three speakers of Damascus Arabic (Haskins lab film 1962), where one speaker exhibits a greater concavity of the tongue, resulting in a deep groove behind the primary articulation, which becomes more evident when the adjacent vowel is a back close /u/ in which case the back of the tongue only raises. This is also evident in MacCurtain's (1982) xeroradiograms of her Iraqi subject when compared to those of Al-Ani's, (1970) and Ali and Daniloff's, (1972).

MacCurtain's xeroradiograms of /T/ in /Ti:n/, as said by her Iraqi subject, show a very considerable rearward and upward movement by the back of the tongue. No lateral radiographic evidence so far of any Arabic dialect showed this unique configuration of the articulators for the pharyngealized consonants. One can almost say that /T/ in this case, is produced by two closures, the first in the front of the vocal tract, and the second by the back of the tongue, against the back wall of the pharynx at the level of C2. McCurtain's xeroradiogram also shows that the cavity below the great constriction, just a little above the epiglottis, widens considerably to create a very large larynopharyngeal cavity. The pharyngeal cavity above that is almost non-existent. The larynx is raised. The dimension of the

laryngopharyngeal cavity is altered, probably as a result of the raising of the larynx and the pressure exerted by the backward movement of the tongue.

An important question that arose in the analysis with regard to the consonants and the adjacent vowels (in particular, the open vowels /a:/ and /ɑ:/) was whether to attribute the constriction in the pharynx and the other characteristics of pharyngealization to the consonant or the vowel. The conclusion reached was that this phenomenon is not attributable to either the consonant or the vowel, but to both, and any attempt to separate the two is more or less impossible. One can only treat the pharyngealized sounds in terms of the syllable CV or VC. In TA, the coarticulatory effects of the primary pharyngealized consonants extend over any adjacent vowel or consonant as long as they are within the syllable. If the coarticulatory effect is found to extend over an adjoining syllable, then the latter must contain a low front open vowel /a/ or /a:/. If the adjoining syllable contains a close vowel /i/, /i:/ or /u/, /u:/, then the coarticulatory effect does not extend beyond the first syllable. The coarticulatory effect is bidirectional in that if the second syllable contains a pharyngealized consonant, the coarticulatory effect is only anticipated in the first syllable if this contains an open vowel; if it contains a close vowel, then there is no anticipatory coarticulatory

effect in the first syllable. The effect starts at the beginning of the second syllable and increases towards the pharyngealized segment.

If the pharyngealized syllable contains a close vowel, then the effect of this segment does not extend beyond this syllable to the following syllable, even if this syllable contains an open vowel, e.g., /Ti:ba/ 'goodness'. This is only true in the first syllable. If the pharyngealized syllable containing a close vowel is preceded by another syllable, this syllable is pharyngealized whether the vowel is close or open, e.g., /baTi:ʔ/ 'slow'. This leads to the conclusion that R - L (Right to Left) coarticulation is more extensive than L - R (Left to Right). This is in agreement with Ghazeli, (1977), who found that "R - L backing gesture extends over the entire word and is coterminous with it in all the dialects. Although palatal vowels, especially the long ones, can weaken this backing, they do not completely block it. The extent of L - R backing gesture, on the other hand, is highly dependent on vowel quality and duration. The presence of only low vowels in a word containing a pharyngealized consonant secures the propagation of pharyngealization".

Ahmed, (1979), found that 'emphasis' does not extend from one word to another following it, but a preceding word can be influenced by the following word whether the 'focal point' is in the initial or medial position. In other

words, R - L coarticulation is more extensive than L - R.

Ahmed, (1979), and Nasr, (1959), give examples of coarticulation effects extending across word boundary; their description seems to be auditorily based. One tends to agree with other investigators, Ali and Daniloff (1972), and Ghazeli (1977), who found that the influence of retraction never extends across word boundary, but it may extend over the entire word. This is evident from experimental findings of this thesis which show that the influence of the pharyngealized sounds starts to fade away after the segment following the pharyngealized consonant.

Endoscopic analysis of the pharyngealized consonants and the adjacent sounds as said by the four subjects showed the following:

- a) The retraction of the epiglottis towards the back wall of the pharynx
- b) The constriction in the vallecula area followed by the retraction of the root of the tongue close against the epiglottis, which uncurls its upper surface (and the greater the constriction, the more uncurling is observed)
- c) The constriction caused by the side wall movement which is quite considerable in the case of SA.

All subjects exhibited these features, but in various degrees. SA showed the maximum constriction in the pharyngeal area for these sounds.

/r/ and /a/ in, for instance, /raʔa/ have similar articulatory configuration to the pharyngealized consonants, and the uvular /X/ and /g/. The constriction, however, is not as great as that for the pharyngealized consonants and the retraction of the epiglottis is more than for the pharyngealized consonants or the uvulars. In the case, for instance, of /garr/, it is found that the epiglottis and the tongue behave similarly to that of a pharyngealized consonant. It is possible that this is due to the occurrence of /r/ and /a/ and not /g/, as it is found that in all the other examples of the uvulars /X/ and /g/, the epiglottis is not pressed down and then uncurls its tip as it does for a pharyngealized sound. Also, because this configuration does not occur, for instance, in the word /ga:di/ in spite of the presence of the open vowel /a:/.

It is found that /q/ articulatorily is similar to the pharyngealized sounds. One can almost assign to it two places of constriction or articulation, primary at the uvula and secondary at the pharynx at the level of C2. Radiographic evidence can support this claim. As a matter of fact, more constriction is effected for /q/ laterally in the pharynx (endoscopic evidence). One should expect that /q/ will induce retraction to adjacent segments. This retraction

is observed and perceived when /q/ is adjacent to vowel segments, that is, /q/ has the effect of centralizing the front vowels and lowering the close back vowels. In all cases of /q/, adjacent to vowels, this coarticulatory feature is evident whether these vowels precede or follow /q/. This retraction effect is not present for the consonants adjacent to /q/ no matter what the consonant is, except perhaps when /r/ is adjacent to /q/, in which case, /r/ is retracted.

In the examples of /ʔaqfa:l/ 'locks', /ʔaqla:m/ 'pens', /ʔaqda:r/ 'destinies', /ʔanqad/ 'he rescued', /ʔaqsa:m/ 'divisions', no retraction occurs for the segments /l,d,n,s/, but this retraction occurs when they are adjacent to /T/, /D/ or /S/.

However, one could claim a close similarity of /q/ to the pharyngealized sounds on the grounds that this sound requires for its production the closure of the soft palate, and the dorsum of the tongue. This gives a rearward place of articulation, which leaves the front of the tongue free to execute a 'front' consonant. All consonants in the previous examples are made in the front of the vocal tract. In other words, the place of articulation of /q/ does not interfere with the articulation of labials, dentals or alveolars. But the case is otherwise when a pharyngealized consonant occurs with another consonant. The uvular fricatives /X/ and /g/ were observed to have similar pharyngeal configuration

to the pharyngealized consonants, mainly when they are said in isolation. Their effect only extends over an open low vowel. The consonants adjacent to them are not affected, e.g., in /Xla:L/ 'safety pin', /gˤlabˤb/ 'he won'. However, examples with retracted adjacent consonant and vowel can be cited in Xba:r/ 'news', /gˤba:r/ 'dust', /Xma:r/ 'veil', /Xna:g/ 'necklace'. Here one is faced with the problem of deciding which segment is the 'focal point' of this retraction effect. No retraction is perceived in /Xla:l/ and /gˤlabˤb/, nor in /Xi:ma/ 'tent', or /ge:m/ 'clouds'. The retraction effect is only perceived when /X/ or /gˤ/ are adjacent to an open low vowel. Moreover, /b/, /m/ and /n/ in /Xba:r/, /Xna:g/ and /Xma:r/ cannot be 'focal points' of retraction because they lose the retraction effect when they are adjacent to a close front vowel in, for instance, /Xmi:ra/ 'yeast'. In the view of the above, it would seem more convenient to transcribe the vowel adjacent to /X/ and /gˤ/ as /a:/, instead of /a:/. In other words, to consider this vowel as a phoneme like that in the word /x :r/ 'hot' and not an allophonic variation of /a:/ in the environment of the uvular /X/ and /gˤ/. This, however, would raise the problem of which vowel phoneme should be used and when.

The use of the term 'pharyngealization' in this thesis is thus mainly based on there being a constriction in the pharynx, whatever the place may be. It was found that in the case of the uvular consonants, /X/, /gˤ/ and /q/

the constriction is achieved by the retraction of the tongue towards the back wall of the pharynx and raising its dorsum towards the soft palate which leaves a narrow space to produce friction for the voiceless fricatives /x/ and /ç/, with a slightly narrow constriction for /x/. The constriction is made tighter into a closure for the voiceless stop /q/. However, as it is found in the case of subject (JS) in /ba:q/, the constriction extends in the pharynx from the level of the epiglottis to the place of the primary constriction against the soft palate. The constriction in the whole pharynx seems to be of a uniform shape. Nevertheless, endoscopic findings do not show a great constriction of the tongue against the epiglottis as for the pharyngealized consonants or a great rearward movement of the epiglottis towards the back wall of the pharynx as in the case of the pharyngeals.

The pharyngealized consonants with their primary place of articulation in the denti-alveolar and post alveolar regions, do not differ considerably in this respect from their non-pharyngealized counterparts if the secondary articulation is not present, that is, the constriction in the pharynx made mainly by the rearward movement of the tongue, is the main factor which gives these sounds their special characteristics of resonance, affecting all the adjacent vowels and consonants. Other manifestations in the pharyngeal cavity that show the difference between the

pharyngealized and non-pharyngealized consonants lie in the movements of the epiglottis and the lateral walls of the pharynx which are considerably constricted in the case of the pharyngealized group. The other difference lies in the front part of the vocal tract manifested in a slight retraction of the tip or blade of tongue and a firm contact of the sides of the tongue against the upper teeth. Both were evident in palatograms made of these consonants. The wipe-off for the pharyngealized consonants is sharper and more extensive and generally covers the whole denti-alveolar region than for the non-pharyngealized counterparts. Videofluorographic evidence shows that the tongue performs two main movements, first of retraction towards the back wall of the pharynx, and second, of raising or lowering, depending on the adjacent vowel. These seem to occur simultaneously, and to the same degree. Endoscopic observation confirms that the pharyngeal configuration at the level of the epiglottis, remains the same for the pharyngealized consonant as well as the vowel. In some cases, e.g., /Dala:l/ and /Tala:l/, the same pharyngeal configuration was observed for most of the word. The constriction of the root of the tongue is very considerable to the extent that it covers the upper edge of the epiglottis. The constriction is obviously enhanced due to the occurrence of the two open vowels.

In general, /r/ has a similar pharyngeal configuration to the uvular /X/, /g/, and to a lesser extent, /q/. This applies also to the 'pharyngealized' vowels /a:/ and /a:/, and to pharyngeals, that is to say, the epiglottis is more retracted for /r/ than for the uvular or the pharyngealized consonants, but not the same as the pharyngeals. In /raʔa/, for instance, the whole word has the same articulatory configuration in the pharynx.

On the other hand, the maximum constriction of the pharyngeals does not extend to the adjacent vowel. The constriction is eased immediately after the articulation of the pharyngeal segment. When a close vowel is adjacent to the pharyngeal, the epiglottis retracts considerably for the pharyngeal segment, and moves back rapidly for the vowel. But if an open vowel is adjacent to the pharyngeal segment, then the epiglottis takes longer to leave the back wall of the pharynx and cavity between the epiglottis and the back wall of the pharynx remains closer than for a close vowel. In the case of words with a pharyngealized consonant, for instance, in /ʔaDD/, the influence of the pharyngealized segment /DD/ is evident in the initial segment /ʔ/. Besides the considerable approximation of the epiglottis against the back wall of the pharynx, its upper edge is observed to uncurl considerably, as in the pharyngealized consonants. The whole word shares the characteristics of lower pharyngeal configuration of both /ʔ/ and /DD/.

Spectrographic analysis of /~~ʌ~~aDD/ showed that F2 is lowered for the whole word.

In spite of the obvious similarities among these three groups of consonants, each have their own characteristic features which even though they are manifested in various degrees, they retain their identity and remain distinct from the other groups.

Suggestions for future research:

It would be interesting to study the production of the pharyngeal consonants crossdialectally, in particular, the voiced pharyngeal fricative /3/.

Variations related to this consonant exist in the pronunciation of speakers of the same geographical area. However, these variations are considerable between Eastern and Western dialects in general and Bedouin and urban dialects in particular.

The investigation of these sounds would help to offer some solutions to controversial issues if certain experimental techniques were used to produce simultaneous records. For instance, fiberoptic endoscopy, with an overlay of the laryngographic waveform of voicing as combined in the video tape made of Xhosa epiglottic trills (Traill and Anthony made in 1978 and referred to in Chapter 4). This 'Lx' overlay with videofluorography would also be very informative, but the main requirement in future work will be simultaneous video records of endoscopy and fluorography (as used clinically in cleft palate work at the Frenchay Hospital in Bristol) and a timing channel common to all the techniques of observation and measurement used, to allow each changing articulatory movement and its consequence in the changing airflow from the lungs and the acoustic structure of speech from the mouth to be followed from instant to instant.

It would be interesting, too, to study the simultaneous movements of the muscles using EMG to determine the patterns of innervation involved in the movements of the structures.

One should advise that it is essential to apply a coating of barium to the articulators during a radiographic investigation to produce well-defined structures, especially in the front part of the vocal tract.

A new experimental investigation should concentrate on the study of vowels in isolation to determine the coarticulation effect of adjacent segments.

Variations related to male-female speech, particularly in relation to the pharyngealized consonants, would shed light on this other aspect of the phenomenon of pharyngealization.

Axial radiographic study of the sounds investigated in this thesis may establish the extent of side wall movement and exactly where this movement takes place. Endoscopic observation, by itself cannot, unfortunately, establish where side wall movement takes place for these sounds. Side wall movement of the pharyngeal consonants, on the other hand, was easy to determine because in the production of these sounds, there is a sphincteric constriction of the pharynx confined to the level of the epiglottis.

The great side wall movement during the production of the uvular stop /q/ takes place at a superior position in the pharynx and here again it is difficult to determine the exact place by endoscopic observation alone.

This is also the case in the production of other sounds where side wall movement occurs in various degrees and at different levels.

APPENDIX I

- a. Parameters from xeroradiographic analysis
 1. Distance between epiglottis and back wall of pharynx at narrowest point
 2. Distance between tip of epiglottis and back wall of pharynx
 3. Maximum horizontal dimension of space between root of tongue to front face of epiglottis
 4. Distance between tongue root and back wall of pharynx at narrowest point
 5. Distance between the top of the body of the hyoid and nearest cervical vertebra
 6. Distance between superior surface of tongue dorsum and palate at narrowest point
 7. Distance between soft palate and back wall of pharynx at narrowest point
 8. Distance between the front edge of C1, C2, C3 and back wall of pharynx
 9. Vertical distance from zygomatic arch (a) bone to inferior border of cricoid cartilage (b).
 10. Minimum distance between the upper and lower lips

1 2 3 4 5 6 7 8 9 10

At rest	9	16	6	15	34	0	14	3 3 4	139	0
ti:n	14	21	19	22	38	2	0	6 3 4	136	7
Ti:n	17	24	9	20	38	2	0	6 3 4	137	7
walla	8	12	2	11	39	14	0	6 3 4	134	9
waLLa	8	11	1	5	41	1	0	5 3 4	135	10
maʒʒana	1	6	7	10	40	15	3	5 3 4	130	16
maʕʕana	1	5	5	10	43	43	0	6 3 4	127	17
riqqa	5	8	3	5	37	0	0	4 3 4	127	5

- b. Features from radiographic and endoscopic analysis.
1. Retraction of the epiglottis towards the back wall of the pharynx. None, some, considerable.
 2. Degree of uncurling of the upper edge of the epiglottis. None, some, considerable.
 3. Shortening of the stem of the epiglottis. None, some, considerable, uncertain.
 4. Retraction of the tongue root towards the back wall of the pharynx. None, some, considerable.
 5. Degree of lateral wall movement. None, some, considerable.
 6. Level of lateral wall movement. Low, high.
 7. Types of soft palate position. (Figure 7.3)

	И	3
1.	considerable	considerable
2.	none	none
3.	considerable	considerable
4.	some	some
5.	considerable	considerable
6.	low	low
7.	T4	T4

	q	x	g
1.	some	some	some
2.	considerable	none	none
3.	considerable	uncertain	uncertain
4.	some	some	some
5.	considerable	some	some
6.	high	low	low
7.	T5	T5	T5

t	T	d	D	S	Z	Z	L	L
1	some	some	some	some	some	some	some	some
2	none	cons.	none	cons.	none	cons.	none	cons.
3	none	uncertain	uncertain	uncertain	uncn.	uncertain	none	some
4	some	some	some	some	some	some	some	some
5	some	some	some	some	some	some	some	some
6	low	low	low	low	low	low	low	low
7	T6	T5	T5	T5	T5	T5	T5	T5

c. Features from Airflow analysis.

- | | | |
|----|-----------------------|--------------------|
| 1) | Presence - voicing | yes, no |
| 2) | Presence - aspiration | yes, no |
| 3) | Presence - frication | yes, no |
| 4) | Peak - nasal flow | no, low, high |
| 5) | Volume - nasal | none, small, high |
| 6) | Volume - oral | none, normal, high |

	h	3
1.	no	yes
2.	yes	no
3.	no	no
4.	high	low
5.	high	small
6.	normal	normal

	q	X	g
1.	no	no	yes
2.	no	yes	no
3.	no	yes	no
4.	no	no	low
5.	none	none	small
6.	none	high	normal

t T d D S L L

1	no	no	yes	yes	no	yes	yes
2	no	no	no	no	no	no	no
3	no	no	no	no	yes	no	no
4	no	no	no	no	no	low	low
5	none	none	none	none	none	small	small
6	none	none	none	none	normal	normal	normal

APPENDIX II

The data:

/be:n/	'between'
/ba:ɳ/	'he revealed'
/ba:ʒ/	'he sold'
/ba:q/	'remaining'
/baddaʒ/	'he innovated'
/baDDaʒ/	'he shopped'
/baTa:Ta/	'potatoes'
/baɳɳa/	'hoarseness'
/bugʒa/	'stain'
/ti:n/	'figs'
/Ti:n/	'mud'
/ti:r/	'lead balls'
/Ti:r/	'fly (m. sg. imp.)'
/Te:f/	'phantom'
/ta:b/	'he repented'
/Ta:b/	'it (m. sg) cooked'
/Tala:l/	'a proper name'
/to:r/	'bull'
/To:r/	'group'
/tu:b/	'repent (m. sg. imp.)'
/Tu:b/	'bricks'
/tla:t/	'Tuesday'
/di:r/	'make (m. sg. imp.)'

/Di:g/	'narrowness'
/damm/	'blood'
/Damm/	'he tidied up'
/dahr/	'century'
/Dahr/	'back'
/Daħħa/	'he sacrificed'
/dala:l/	'coquetry'
/Dala:l/	'backsliding'
/dull/	'degradation'
/Dull/	'shade/shadow'
/du:d/	'worms'
/du:r/	'turn (m. sg. imp.)'
/ki:f/	'how'
/kiswa/	'suit'
/ka:f/	'the name of the letter k'
/kalb/	'dog'
/kaħħ/	'he coughed'
/ħaħħa/	'a cough'
/kaħħa:ħa/	'cough'
/ku:ʒ/	'elbow'
/gi:m/	'pick up (m. sg. imp.)'
/ga:d/	'he led'
/ga:D/	'he has undone'
/ga:s/	'he measured/trying'
/ga:S/	'he has cut'
/gaZZa/	'sea-sand'
/gult/	'I/you said'

/gu:d/	'lead (m. sg. imp.)'
/gwi:/	'strong'
/qi:ma/	'value'
/qiTa:r/	'train'
/qalb/	'heart'
/qalam/	'pen'
/qalamh ib ir/	'pen'
/qur?a:n/	'Koran'
/ʔalam/	'pain'
/ʔaLLa/	'God'
/ʔa h na/	'a word used to stop children from doing something'
/mitla h fa/	'wrapped (f. sg.)'
/ma h ana/	'he has tested'
/ma33ana/	'he has considered attentively'
/ma:r/	'common'
/ma:r/	'passing'
/maTbiX/	'kitchen'
/marra/	'ounce'
/maSS/	'he sucked'
/mo:za/	'banana'
/mo:z/	'waves'
/mu:s/	'knife'
/niqma/	'vengeance'
/na:r/	'it lit (m. sg.)'
/na:r/	'fire'
/na:git/	'she'

/na:ʒiT/	'active'
/no:m/	'sleep'
/nu:D/	'get up (m. sg. imp.)'
/nuXXa:la/	'bran'
/nDi:f/	'clean'
/li:m/	'orange/lemon'
/le:l/	'night'
/lo:m/	'blame'
/lbint raqi:qa/	'the girl is delicate'
/ligde: Ta:b/	'lunch is cooked'
/ri:ħ/	'wind'
/riqqa/	'delicacy'
/rabb/	'God'
/raqi:q/	'delicate'
/ra?a/	'he saw'
/raħa/	'he ground'
/raʒa/	'he tended (the sheep)/protected'
/rubb/	'treacle'
/fikk/	'undo (m. sg. imp.)'
/fi:g/	'wake up (m. sg. imp.)'
/fa:g/	'he woke up'
/fa:s/	'axe'
/fari:q/	'team'
/si:n/	'the name of the letter s'
/Si:n/	'China'
/Si:m/	'fast (m. sg. imp.)'
/simm/	'poison'

/se:f/	'sword'
/Se:f/	'summer'
/sa:m/	'poisonous'
/Sa:m/	'he fasted'
/so:m/	'price'
/So:m/	'fasting'
/sama:h/	'forgiveness'
/sama:3/	'hearing'
/sama:~/	'sky'
/sa:n/	'he has sharpened (knife)'
/Sa:n/	'he protected'
/Sa:X/	'he fainted'
/Sa:g/	'he made jewellery'
/Su:n/	'protect'
/sabr/	'probing'
/Sabr/	'patience'
/salb/	'robbery'
/Salb/	'crucification'
/sa h it/	'it (the rain) stopped'
/Sa h ia/	'health'
/s h a:b/	'clouds'
/S h a:b/	'friends'
/sa33ala/	'he coughed'
/sa??ala/	'he asked'
/ssme: Sa:fia/	'the sky is clear'
/SSu:ra h ilwa/	'the picture is beautiful'
/za h ma/	'crowded'

/Za:biT/	'officer'
/Zo:z/	'two'
/sih/	'pull (m. sg. imp.)'
/sahha/	'he pulled it'
/su:f/	'see (m. sg. imp.)'
/zi:b/	'bring (m. sg. imp.)'
/za:ri/	'liquid/running'
/za:ri/	'my neighbour'
/Xirba/	'ruin'
/Xe:T/	'thread'
/Xa:tim/	'ring'
/Xass/	'he entered'
/Xuss/	'enter (m. sg. imp.)'
/XSurr/	'he lost'
/Xass. lda:Xil/	'he came inside'
/ga:di/	'there'
/guDwa/	'tomorrow'
/gu:l/	'ghost'
/garr/	'he deceived'
/ga:S/	'it sank'
/gass/	'he cheated'
/nilim/	'dream'
/ne:T/	'wall'
/nadd/	'nobody'
/naDD/	'luck'
/nakk/	'he rubbed'
/naki:m/	'wise'

/ʔazz/	'he stopped (a fight)'
/ʔazz/	'pilgrimage'
/ʔarka/	'movement'
/ʔo:l/	'year'
/ʔuSSa/	'share'
/ʔukk/	'rub (m. sg. imp.)'
/ʔi:d/	'feast'
/ʔidd/	'count (m. sg. imp.)'
/ʔilim/	'knowledge'
/ʔadd/	'he counted'
/ʔaDD/	'he bit'
/ʔalam/	'flag'
/ʔe:n/	'eye'
/ʔu:d/	'twig'
/ʔTe:/	'he gave'
/ʔre:/	'bare'
/waʔd/	'to bury alive'
/waʔʔada/	'he buried alive'.
/walla/	'he returned'
/waLLa/	'God'
/walla fi:ssaʔ/	'he returned quickly'
/waLLa lʔaDi:m/	'By God, the great'
/waʔʔada/	'he united'
/waʔʔada/	'he made a promise'
/ytill/	'he pulls'
/yTull/	'it overlooks'

Bibliography

- Abercrombie, D., (1957) 'Direct palatography',
Studies in Phonetics and Linguistics.
Oxford University Press, 125-130.
- Abercrombie, D., (1976) Elements of General Phonetics,
Edinburgh University Press.
- Adamson, B., (1980) 'A spectrographic analysis of
pharyngeal consonants in Sudanese
Arabic', Work in Progress.
University of Reading, 81-96.
- Ahmed, A. A., (1979) A Phonetic Study of Men's and
Women's Speech, with Reference to
Cairene Arabic, M. Phil. thesis,
University of Leeds.
- Al-Ani, S. H., (1970)a Arabic Phonology: An Acoustical
and Physiological Investigation,
The Hague, Mouton.
- Al-Ani, S. H., (1970)b 'An acoustical and physiological
investigation of the Arabic /ʕ/',
Actes du X^e Congrès International
Des Linguistes, 1967 Bucarest,
155-166. Also, in Al-Ani, S. H.,
(Ed.), (1978), Readings in Arabic
Linguistics, Indiana University
Linguistics Club, 89-101.

- Al-Ani, S. and May, R., (1978) 'The phonological structure of the syllable in Arabic', Readings in Arabic Linguistics, Al-Ani, S., (Ed.). Indiana University Linguistics Club, 103-112.
- Ali, L. and Daniloﬀ, R., (1972)a 'A cinefluorographic-phonologic investigation of emphatic sound assimilation in Arabic'. Proceedings of the International Congress of Phonetic Sciences, 7; 639-48.
- Ali, L. and Daniloﬀ, R., (1972)b 'A contrastive cinefluorographic investigation of the articulation of emphatic - non-emphatic cognate consonants'. Studia Linguistica 26: 81-105.
- Al-Jazary, Z. M. H., (1981) An Experimental Study of Vowel Duration in Iraqi Arabic, Ph. D. thesis, University of Leeds.
- Amerman, J. D., (1970) A Cinefluorographic Investigation of the Coarticulatory Behaviours of the Apex and Body Lingual Articulators, Ph. D. thesis, University of Illinois.
- Anis, E., (1961) Al-Aswat-al-Lughawiyya, (3rd. edn.), Dar -al-Nahda al-Arabiyya, Cairo.

- Anthony, J., (1954) 'A new method of investigating the tongue positions of consonants'. Science Technologist's Bulletin, Oct. - Nov., 2-5.
- Anthony, J., (1968) 'Later thoughts on direct-palatography', Work in Progress. Department of Phonetics and Linguistics, Edinburgh University, 2: 49-52.
- Anthony, J., (1980) 'Aerodynamic and phonetic analysis'. Advances in the Management of Cleft Palate. Edwards and Watson, (Ed.), Churchill-Livingstone. Edinburgh.
- Anthony, J., (1982) Breathing and Speaking: The Modification of Respiration for Speech. Ph. D. thesis, University of Edinburgh.
- Arnold, G. E., (1957) 'Morphology and physiology of the speech organs'. Manual of Phonetics, Kaiser, (Ed.), North-Holland Publishing Company, Amsterdam.

- Azzopardi, M., (1980) 'New apparatus for the study of visual patterns in speech'. Work in Progress. Linguistics Department, Edinburgh University 13: 117-119.
- Azzopardi, M., (1982) The Phonetics of Maltese; Some Areas Relevant to the Deaf. Ph. D. thesis, University of Edinburgh.
- Baird, J. L., (1927) British Patent No. 20, 969.
- Bakalla, M. H., (1975) Bibliography of Arabic Linguistics, Mansell.
- Ballantine, J. M., and Allan, W. B., (1965) 'Fibreoptics'. Science Journal.
- Beckett, R. L., and Halett, S., (1971) 'An investigation of airflow in relation to placement for vowel production'. Phonetics 23: 34-41.
- Bell, A. G., (1908) The Mechanism of Speech. Funk and Wagnalls, New York.
- Blanc, H., (1953) Studies in North Palestinian Arabic. Central Press, Jerusalem.

- Bonnot, J. F., (1977) 'Recherche experimentale sur la nature des consonnes emphatiques de l'Arabe classique', Travaux de L'Institut de Phonétique de Strasbourg 9: 47-88.
- Bonnot, J. F., (1979) 'Etude expérimentale de certains aspects de la gemination et de l'emphase en Arabe', Travaux de L'Institut de Phonétique de Strasbourg 11: 109-118.
- Borden, G., and Harris, K., (1980) Speech Science Primer: Physiology, Acoustics, and Perception of Speech. Williams and Wilkins, Baltimore.
- Bosma, J., and Fletcher, S., (1962) The upper pharynx: a review, Part II, Physiology. Annals of Otology, Rhinology and Laryngology 71: 134-157.
- Brosnahan, L. F., and Malmberg, B., (1976) Introduction to Phonetics. Cambridge University Press.
- Browne, L., and Behnke, E., (1887) Voice, Song and Speech. (6th Edn.). Putman's Sons, New York.

- *Bruno, D. Grammatica Pratica della Lingua Araba Parlata in Tripolitania. Bologna.
- Cagliari, L. C., (1978) An Experimental Study of Nasality with Particular Reference to Brazilian Portuguese. Ph. D. thesis, University of Edinburgh.
- Catford, J. C., (1968) 'Articulatory possibilities of man!', Manual of Phonetics, Malmberg, B., (Ed.). North-Holland Publishing Company, Amsterdam.
- Catford, J. C., (1977) Fundamental Problems in Phonetics. Edinburgh University Press.
- Catford, J. C., (1981) 'Pharyngeal and laryngeal sounds in Caucasian languages'. Paper submitted for Conference on Vocal Fold Physiology. Madison, Wisconsin.
- Carmody, F. J., (1941) 'An X-ray study of pharyngeal articulation'. University of California Publications in Modern Philology 21: 5: 377-384.
- *Cesaro, A., (1939) L'Arabo Parlato a Tripoli. Milano.
- Chapman, W. H., (1973) Introduction to Practical Phonetics. Horsley's Green, England.

- Collins, B. H., (1970) Lateral Pharyngeal Wall Activity.
Unpublished dissertation.
University of Missouri.
- Coady, J., (1967) Emphasis in Four Arabic Dialects:
An Acoustic Study. M. A. dissertation.
University of Indiana,
Bloomington.
- *Crawford, K., The Spoken Arabic of Tripoli,
Libya. Washington, D. C.
- Cunningham's Text-Book
of Anatomy, (1953) James Couper Brash, (Ed.).
Oxford University Press.
- *Curotti, T., Il Dialetto Libico, Tripoli.
- Curry, S. S., (1910) Mind and Voice. Expression Co.:
Boston.
- Cowan, W., (1961) 'Loss of emphasis' Journal of
Maltese Studies. Malta University
Press 3: 27-32.
- Daniloff, R. G., and
Hammarberg, R. E., (1973) 'On defining coarticulation',
Journal of Phonetics 1: 239-48.
- Dechicha, F., (1978) A Phonetic Study of the Vowels in
the Arabic Dialect of Algiers. M.
Litt. thesis, University of Edin-
burgh.

- Delattre, P., (1962) 'Some factors of vowel duration and their cross-linguistic validity'. Journal of the Acoustical Society of America 34: 1141-43.
- Delattre, P., and Freeman, D., (1968) 'A dialect study of American R's by X-ray motion picture. Linguistics 44.
- Delattre, P., (1971) 'Pharyngeal features in the consonants of Arabic, German, Spanish, French and American English'. Phonetica 23: 129-55.
- Delattre, P., (1981) Studies in Comparative Phonetics. Malmberg, B., (Ed.). Julius Groos Verlag, Heidelberg.
- Dickson, D., and Dickson, W., (1972) 'Velopharyngeal Anatomy'. Journal of Speech and Hearing Research 15: 372-381.
- Elfitouri, A., (1976) A Descriptive Grammar of Libyan Arabic. Ph. D. thesis, University of Washington.
- Fant, G., (1957) 'Modern instruments and methods for acoustic studies of speech'. Proceedings of the 8th International Congress of Linguists, Oslo. 282-388.

- Fant, G., (1966) 'A note on vocal tract size factors and non-uniform F-pattern scalings, Quarterly Progress and Status Report 4: 22-30. Speech Transmission Laboratory, Royal Institute of Technology, Stockholm.
- *Farina, G., Grammatica Araba per la Lingua Letteraria con un Appendici sul Dialetto Tripolino. Heidelberg.
- Ferguson, C. A., (1956) 'The emphatic l in Arabic'. Language 32: 446-52.
- Firth, J. R., (1957) Papers in Linguistics 1934-1951. Oxford University Press.
- Fleish, A., (1925) 'Pneumotachograph: Apparatus for recording respiratory flow'. Archiv für die gesamte Physiologie 209: 713.
- Fletcher, S. G., (1957) A Cinefluorographic Study of the Movements of the Posterior Wall of the Pharynx During Speech and Deglutition. M. S. thesis, University of Utah.

- Fritzell, B., (1969) 'The velopharyngeal muscles in speech: an electromyographic and cineradiographic study. Acta Otolaryngologica. Supplement 250: 1-81.
- Fujimura, O., (1977) 'Stereo-fiberscope', Dynamic Aspects of Speech Production, University of Tokyo Press, 133-137.
- Gaber, A. M., (1972) The Phonology of the Verbal Piece in Cairo Egyptian Arabic. Ph. D. thesis, University of London, SOAS.
- Gairdner, W. H. T., (1925) The Phonetics of Arabic. Oxford University Press.
- Gauffin, J., and Sundberg, J., (1978) 'Pharyngeal constrictions'. Phonetica 35: 157-168.
- Ghazeli, S., (1977) Back Consonants and Backing Coarticulation in Arabic. Ph. D. thesis, University of Texas.

- Greene, M. C. L., (1964) The Voice and its Disorders,
(2nd Edn.), Pitman Medical,
London.
- Greenberg, J., (1950) 'The patterning of root morphemes
in Semitic'. Word 6: 162-181.
- Griffini, E., (1913) L'Arabo Parlato della Libia.
Ulrico Hoepli: Milano.
- Hagerty, R. F., Hill, M.
J., Pettit, H. S., and
Kane, J. J., (1958) 'Posterior pharyngeal wall move-
ment in normals'. Journal of
Speech and Hearing Research
1: 203-210.
- Hagerty, R. F., and
Hill, M. H., (1960) 'Pharyngeal wall and palatal
movement in postoperative cleft
palate and normal palates'.
Journal of Speech and Hearing
Research 3.
- Hardcastle, W. J., (1976) The Physiology of Speech Produc-
tion. Academic Press. New York.
- Harris, Z. S., (1942) 'The phonemes of Moroccan Arabic'.
Journal of the American Oriental
Society 62: 309-318.

+Haskins Laboratories X-ray Film of Damascus Arabic, (1962).

- Heffner, R., (1950) General Phonetics. University of Wisconsin Press, Madison.
- Hegedüs, L., (1959) 'Beitrag zur frage der geminaten'.
Zeitschrift für Phonetik 12:
68-106.
- Hetzron, R., (1969) 'Two notes on Semitic laryngeals in East Gurage'. Phonetica 19: 69-81.
- Hewlett, N., and Anthony, J., (1982) 'Airflow and voicing characteristics in some segment types'.
Work in Progress Department of Linguistics, University. Edinburgh 15: 100-118.
- Hopkins, H. H., and Kapany N. S., (1954) 'A flexible fibre-scope, using static scanning'. Nature 43-92.
- Jakobson, R., (1973) 'mufaxxama: the emphatic phoneme in Arabic', Phonology. Pulgram, (Ed.).

- Jones, D., (1969) An Outline of English Phonetics,
(9th Edn.), Heffer, Cambridge.
- Jones, S., (1931) 'Somali h and ʔ. Le Maître
Phonétique, 3^E SÉR. 33-56.
- Kahn, M., (1975) 'Arabic emphatics: the evidence
for cultural determinants of
phonetic sex-typing'. Phonetica
31: 38-50.
- Kaplan, H. M., (1960) Anatomy and Physiology of Speech,
McGraw-Hill, New York. Also,
(1971), (2nd. edn.).
- Kiritani, S., (1971) 'X-ray monitoring of the position
of the fiberscope by means of
computer controlled radiography'.
Annual Bulletin. Research Institute
of Logopedics and Phoniatrics,
University of Tokyo 5: 35-39.
- Klatt, D., and
Stevens, K., (1969) 'Pharyngeal consonants'.
Quarterly Progress Report.
Research Laboratory of Electronics,
MIT. 93: 207-216.

- Krieg, L.,
Benson, P., and
Catford, J., (1980) 'Acoustic parameters of plain
and pharyngealized fricatives
in a dialect of Libyan Arabic.'
Phonetics Laboratory, University
of Michigan. A revised version
of the abstract in Journal of
the Acoustical Society Society
of America 67. s 39 (1980).
- Ladefoged, P., (1957) 'Use of palatography', Journal of
Speech and Hearing Disorders 22:
764-774.
- Ladefoged, P., (1971) Preliminaries to Linguistic
Phonetics, University of Chicago
Press.
- Ladefoged, P.,
Clerk, J., and
Harshman, R., (1971) 'Control of the tongue in vowels'.
Proceedings of the Seventh Inter-
national Congress of Phonetic
Sciences, Montreal.
- Ladefoged, P., (1979) 'Articulatory parameters'.
UCLA Working Papers in Phonetics
45: 25-31.

- Laufer, A., and
Condax, I. D., (1981) 'The function of the epiglottis
in speech'. Language and Speech.
24/1 39-69.
- +Laufer, A., and
Condax, I. D., video
tape, (1987) 'The epiglottis as an articulator',
(Copy (1982) University of Hawaii).
- Laver, J., (1980) The Phonetic Description of Voice
Quality, Cambridge University
Press.
- Lehn, W., (1963) 'Emphasis in Cairo Arabic',
Language 39: 29-39.
- Lehiste, I., Morton, K.,
and Tatham, M. A., (1973) 'An instrumental study of consonant
gemination'. Journal of Phonetics,
1: 131-148.
- Maamouri, M., (1967) The Phonology of Tunisian Arabic.
Ph. D. thesis, University of
Cornell.
- Marbe, A., (1971) The Phonetics of Modern Hebrew.
Ph. D. thesis, University of
Edinburgh.

- Marçais, P., (1948) 'L'articulation de l'emphase dans un parler Arabe Maghrébin, Annales de L'Institut d'Etudes Orientales de la Faculté des Lettres de l'Université d'Alger, 7: 5.28.
- Marçais, P., (1956) Le Parler Arabe de Djidjelli, Paris.
- Matar, A., (1981) Lahjat al-Badu, Dar al-maarif, Cairo.
- Minifie, F., Hixon, T., Kelsey, C., and Woodhouse, R., (1970) 'Lateral pharyngeal wall movement during speech production'. Journal of Speech Research 13: 584-594.
- Minifie, F., Hixon, T., and Williams, F., (1973) Normal Aspects of Speech, Hearing and Language, Prentice-Hall, Inc., Englewood Cliffs.
- Mitchell, T. F. M., (1952) 'The active participle in an Arabic dialect of Cyrenaica'. Bulletin of the School of the oriental and African Studies. University of London 14.

- Mitchell, T. F. M., (1956) An Introduction to Egyptian Colloquial Arabic.
- Mitchell, T. F. M., (1975) Principles of Firthian Linguistics.
- Moll, K. L., (1960) 'Cinefluorographic techniques in speech research'. Journal of Speech and Hearing Research 3: 227-241.
- Mackay, I., (1976) Ultrasonic Investigation of Anterior Pharyngeal Wall (Tongue Root) Position in Syllables Containing Tense and Lax Vowels. Ph. D. thesis, University of Cincinnati.
- MacCurtain, F., (1982) Pharyngeal Factors Influencing Voice Quality. Ph. D. thesis, University of London.
- Nasr, R., (1959) 'Velarization in Lebanese Arabic'. Phonetica 4: 203-9.
- Obrecht, D., (1968) Effects of the Second Formant on the Perception of Velarization Consonants in Arabic. The Hague, Mouton.

- Obrecht, D., (1970) 'Factors in the perception of some unvoiced stops in Arabic'.
Word 26: 230-43.
- Obrecht, D., (1972) Review of Al-Ani, S. Arabic Phonology (1970). Language 48: 729-30.
- O'Connor, J. D., (1973) Phonetics. England.
- Odisho, E., (1973) The Role of the Rear Section of the Vocal Tract in Baghdadi Arabic.
M. Phil. thesis, University of Leeds.
- Painter, C., (1979) An Introduction to Instrumental Phonetics. University Park Press. Baltimore.
- Panetta, E., (1943) L'Arabo Parlato a Benghazi.
La Libreria della Stato, Roma
I and II.
- Perkell, J. S., (1969) Physiology of Speech Production.
Research monograph, M.I.T. Press
53.

- Podvinek, S., (1952) 'The physiology and pathology of the soft palate'. Journal of Laryngology and Otology 66: 452-461.
- Pulgram, E., (1965) 'Consonant cluster, consonant sequence and the syllable' Phonetica 13: 76-81.
- Ridwan (1976) Nadarat fi-llugha, University of Garyunis Publications.
- Romanes, G., (Ed.). (1975) Cunningham's Manual of Practical Anatomy 3, Head and Neck and Brain, (13th edn.), Oxford University Press.
- Russell, O. G., (1931) Speech and Voice, New York.
- Sawashima, M., and Hirose, H., (1968) 'New laryngoscope technique by use of fiber optics'. Journal of the Acoustical Society of America 43/1: 168.
- Sawashima, M., and Ushijima, T., (1977) 'Use of fiberscope in speech research'. Annual Bulletin Research Institute of Logopedics and Phoniatics. University of Tokyo.

- Sawashima, M., (1977) 'Fibreoptic observation of the larynx and other speech organs'. Dynamic Aspects of Speech Production. University of Tokyo Press, 31-46.
- Semaan, K., (1963) Arabic Phonetics Sh. Muhamed Ashraf, Kashmir Bazar, Lahore.
- Semiloff, Z., (1975) 'An acoustic - perceptual study of modern Hebrew 'alef' and 'ayin'. Journal of Phonetics 3.
- Shaheen, K., (1979) The Acoustic Analysis of Arabic Speech, Ph. D. thesis. University of Wales, Bangor.
- Stetson, R., (1951) Motor Phonetics. North-Holland Publishing Company, Amsterdam.
- Subtelny, J. D., Pruzansky, S., and Subtelny, J., (1957) 'The application of roentgenography in the study of speech'. Manual of Phonetics, Kaiser, K., (Ed.). Amsterdam.
- Sweid, A., (1977) Al-khawas Attarkibiyya li-Lahjat Tarabulus al-Gharb M. A. dissertation, University of Cairo.

- Tellisi, K. M., Hikayat Madinat Tarabulus lada Arrahala al-Arab wa al-Ajanib Addar al-Arabiyya lil-Kitab, Tripoli, Libya.
- +Traill, A and Anthony, J., video tape of Xhosa epiglottic trills, (1978).
- *Trombetti, (1912) Manuale dell' Arabo Parlato a Tripoli. Bologna.
- Willmore, J. S., (1905) The Spoken Arabic of Egypt, London.
- Zagzebski, J. A., (1975) 'Ultrasonic measurement of lateral pharyngeal wall motion of two levels in the vocal tract'. Journal of Speech and Hearing Research. 18: 308-318.
- Zemlin, W. R., (1964) Speech and Hearing Science. Stipes, Champaign, Illinois. Also, (1968), Englewood Cliffs, New Jersey.

+ By kind permission of Dr. J. Anthony.

* Not available for consultation.